

**FINAL
ENVIRONMENTAL IMPACT STATEMENT**

**L-Reactor Operation
Savannah River Plant**

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APPENDIX A

NEED FOR DEFENSE NUCLEAR MATERIALS, PLANNED PRODUCTION ACTIVITIES, AND PRODUCTION ALTERNATIVES

This appendix is classified because it contains information specifically determined by the Atomic Energy Act to be kept secret in the interest of national defense. This appendix has been prepared for review by the DOE decisionmaker to assure that he has access to all pertinent information when he makes the decision. This appendix is being safeguarded and restricted from public dissemination in accordance with the CEQ Regulations for Implementing the Procedural Provisions of NEPA [40 CFR 1507.3(c)] and DOE's guidelines for complying with NEPA (45 FR 20694).

APPENDIX B

RADIATION DOSE CALCULATION METHODS AND ASSUMPTIONS FOR NORMAL L-REACTOR OPERATION

The normal operation of L-Reactor and its support facilities will result in releases of radioactive materials. This appendix describes the methods and assumptions used to determine the radiological impacts expected from these normal releases.

Radioactive materials released to the environment generally become involved in a complex series of physical, chemical, and biological processes. The principal pathways by which radioactivity released from a facility can reach people are (1) exposure to nuclides in the air, in the water, or on the ground, (2) the inhalation of radioactivity, and (3) the ingestion of radioactivity in food and water. Figure B-1 shows these pathways.

The calculations of radiological doses to members of the public from these various pathways are based on methods recommended by the U.S. Nuclear Regulatory Commission (NRC) for licensing power reactors. The estimates of doses are based on detailed analyses of the sources and rates of radioactive releases, and the pathways by which dispersed radioactive materials can result in exposure to people. The NRC methods are adopted to the specific Savannah River Plant (SRP) conditions.

Radiation doses are calculated for the maximally exposed individual, for the regional population within 80 kilometers of the Savannah River Plant, and to the population being served by the Beaufort-Jasper County and Cherokee Hill (Port Wentworth) water-treatment plants. To determine the expected L-Reactor impacts, the calculations were made for both the first and tenth years of L-Reactor operation. The first year was considered because the doses from remobilized cesium-137 are highest in that year; the tenth year was considered because it will take approximately 10 years before the tritium inventory in the reactor, and the resulting releases, reach equilibrium. Also, radioactive liquid releases from the migration of radionuclides from seepage basins to surface streams via ground water will not occur until 4.4 years after L-Reactor operations are resumed. The calculations were made on the basis of continuous exposure to the radionuclides released from the L-Reactor and its support facilities during these years.

The radiation doses have been calculated for a set of reference-case alternatives that consist of once-through cooling with and without seepage basins. A number of other alternatives with different cooling systems that operate with and without seepage basins have been evaluated in the main text of this EIS. The doses associated with these additional alternatives, including the preferred alternative, have been derived from the reference-case analysis presented in this appendix.

TC

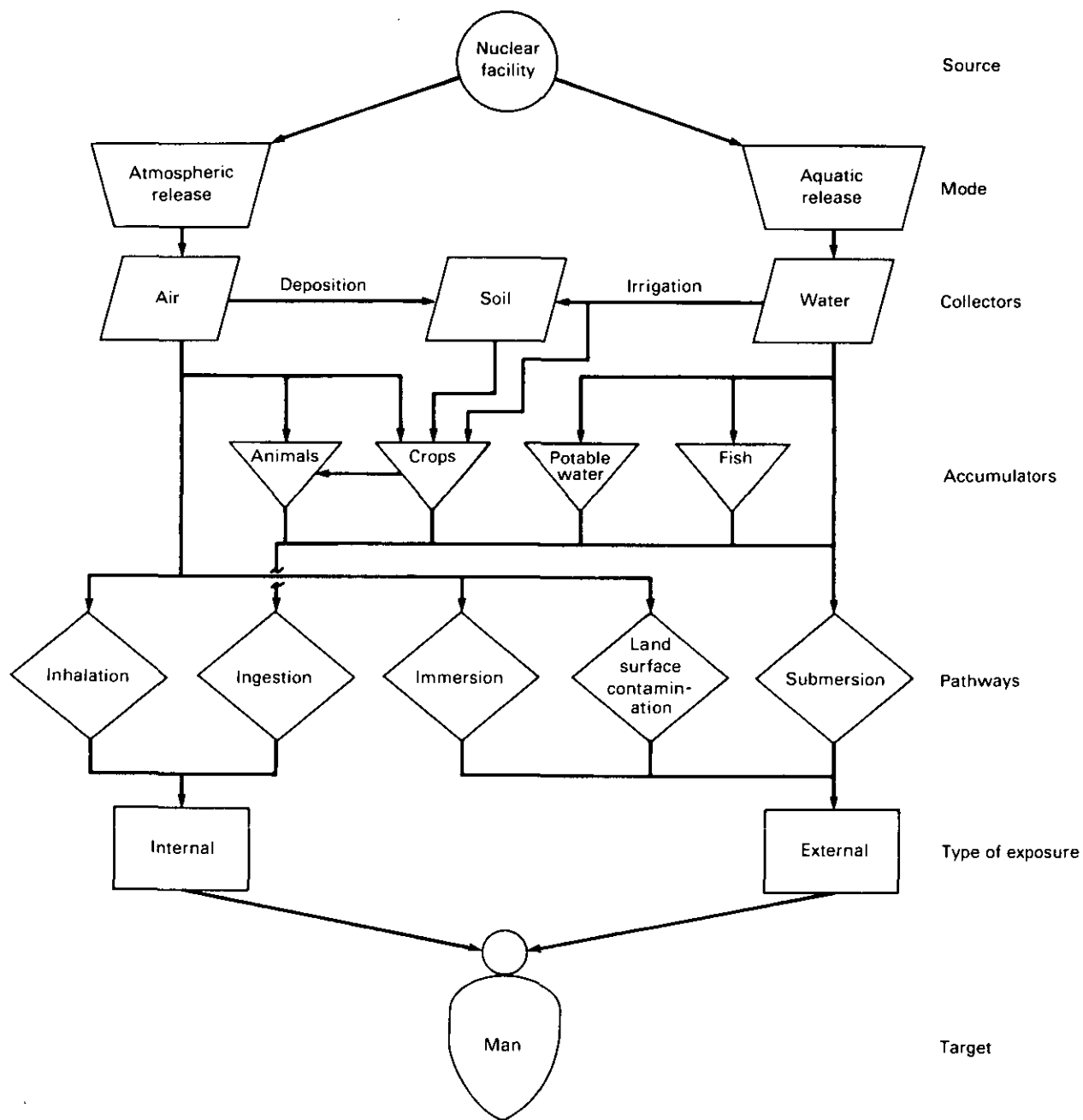


Figure B-1. Exposure pathways considered in radiological impact assessments.

B.1 ATMOSPHERIC RELEASES

For airborne releases, annual average air concentration and ground deposition per unit release (χ/Q and D/Q , respectively) were calculated for each of 160 segments (16 wind direction sectors at 10 distances) within an 80-kilometer radius of the site and for the site boundaries, using the methods implemented in the NRC computer program XOQDOQ (Sagendorf and Gall, 1976). Site-specific meteorological data were used to generate joint-frequency distributions (JFDs) of wind speed, stability, and direction for input to XOQDOQ (Table B-1). These stability windrose statistics were derived by 1-hour averaging of data collected at the 61-meter level of the SRP H-Area meteorological tower during the 5-year period from 1975 to 1979. Stability class was determined from the observed azimuthal and vertical standard deviations (σ_θ and σ_ϕ). Values of χ/Q and D/Q by compass sector and radial increment from both elevated (61-meter) stack releases and ground-level releases (using the windspeed measured at a height of 61 meters) were calculated and are presented in Tables B-2 and B-3, respectively. Flat terrain was assumed; no credit was taken for plume rise induced by momentum or thermal effects. | TC

The meteorological dispersion parameters obtained by running the XOQDOQ code are used as input to the NRC GASPAR code (Eckerman et al., 1980), which implements the radiological exposure models of Regulatory Guide 1.109 (NRC, 1977) to estimate doses from atmospheric exposure pathways. Population distribution data and milk, meat, and vegetable production distribution data (Table B-4) for the 16 wind direction sectors are also used as input to GASPAR for calculating the dose to the regional population; the term "regional population" refers to those individuals residing within 80 kilometers of the Savannah River Plant. Population projections for the year 2000 are used in this analysis.

Source terms input to the GASPAR code, and used in the calculation of doses to the maximally exposed individual and the regional population, are given in Table 4-8 for the L-Reactor only, and Table 5-11 for L-Reactor support facilities. Source terms are presented for the first and tenth years of L-Reactor operation.

To calculate doses to the population within 80 kilometers, compass-sector average values of χ/Q and D/Q are used. All atmospheric releases are assumed to occur at the center of the site; the population and agricultural production distributions were centered at the same points. These are reasonable assumptions, given the absence of high population densities near either L-Reactor or Separations (F and H) Areas release points. Population doses for each year of operation were calculated as the sum of the doses during that year of operation plus residual doses from radioactivity released during that year, for 100 years into the future. The calculated population dose is referred to as a 100-year environmental dose commitment (EDC) per year of operation. (The EDC concept is discussed later in this appendix.) The total dose received by the exposed offsite population as a result of releases from L-Reactor and its support facilities is calculated by adding the individual dose commitments in the population. Parameters used in calculating doses to the 80-kilometer population are summarized in Table B-5. | TC

For the doses to the maximally exposed individual, the XOQDOQ code and the GASPAR code are combined into a computer procedure to determine the doses at the

Table B-1. Joint-frequency distribution of wind; H-area tower 1975-1979

Wind speed class m/sec	Atmosphere stability class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
0.0 - 2.0	A (very unstable)	0.39	0.32	0.39	0.33	0.32	0.38	0.41	0.40	0.37	0.36	0.40	0.40	0.56	0.61	0.46	0.39	6.49
2.1 - 4.0		0.31	0.28	0.31	0.42	0.59	0.64	0.68	0.48	0.48	0.45	0.49	0.44	0.56	0.63	0.53	0.34	7.62
4.1 - 6.0		0.04	0.05	0.05	0.08	0.18	0.15	0.08	0.08	0.09	0.13	0.17	0.12	0.09	0.09	0.14	0.08	1.64
6.1 - 8.0		0.01	0.00	0.01	0.01	0.03	0.01	0.01	0.00	0.06	0.06	0.01	0.02	0.03	0.02	0.03	0.01	0.31
8.1 - 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.09
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0 - 2.0	B (unstable)	0.09	0.10	0.17	0.13	0.17	0.18	0.14	0.11	0.15	0.11	0.11	0.22	0.22	0.23	0.19	0.13	2.46
2.1 - 4.0		0.19	0.14	0.27	0.39	0.38	0.41	0.36	0.26	0.29	0.26	0.29	0.29	0.37	0.44	0.31	0.28	4.92
4.1 - 6.0		0.05	0.05	0.07	0.26	0.27	0.21	0.13	0.12	0.21	0.24	0.18	0.17	0.16	0.28	0.27	0.18	2.85
6.1 - 8.0		0.02	0.02	0.01	0.04	0.03	0.02	0.00	0.03	0.06	0.05	0.03	0.04	0.05	0.02	0.07	0.03	0.53
8.1 - 12.0		0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.02	0.02	0.01	0.08
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0 - 2.0	C (slightly unstable)	0.12	0.11	0.21	0.19	0.18	0.17	0.16	0.13	0.14	0.16	0.16	0.13	0.25	0.29	0.15	0.18	2.75
2.1 - 4.0		0.20	0.19	0.39	0.62	0.69	0.58	0.45	0.47	0.29	0.36	0.40	0.38	0.66	0.60	0.49	0.35	7.11
4.1 - 6.0		0.11	0.10	0.18	0.50	0.55	0.46	0.23	0.24	0.37	0.44	0.32	0.42	0.47	0.49	0.46	0.23	5.58
6.1 - 8.0		0.01	0.02	0.04	0.18	0.14	0.02	0.06	0.08	0.07	0.11	0.11	0.15	0.18	0.18	0.37	0.19	1.92
8.1 - 12.0		0.01	0.01	0.01	0.01	0.02	0.00	0.00	0.03	0.01	0.02	0.05	0.03	0.10	0.11	0.26	0.09	0.76
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.02
0.0 - 2.0	D (neutral)	0.11	0.10	0.17	0.18	0.17	0.14	0.18	0.18	0.17	0.17	0.16	0.23	0.31	0.32	0.22	0.15	2.98
2.1 - 4.0		0.31	0.34	0.58	0.79	1.02	0.98	0.66	0.70	0.51	0.49	0.82	0.68	0.79	0.88	0.77	0.54	10.87
4.1 - 6.0		0.16	0.16	0.33	0.82	0.78	0.68	0.57	0.62	0.62	0.93	0.73	0.73	0.83	1.14	1.22	0.41	10.73
6.1 - 8.0		0.06	0.04	0.06	0.15	0.08	0.06	0.12	0.17	0.20	0.23	0.23	0.27	0.36	0.50	0.83	0.21	3.56
8.1 - 12.0		0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.02	0.04	0.05	0.08	0.08	0.24	0.37	0.47	0.15	1.53
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.05	0.02	0.00	0.11

Table B-1. Joint-frequency distribution of wind; H-area tower 1975-1979 (continued)

Wind speed class m/sec	Atmosphere stability class	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	
0.0 - 2.0	E (slightly stable)	0.05	0.10	0.16	0.06	0.09	0.06	0.15	0.08	0.19	0.08	0.12	0.16	0.18	0.14	0.11	0.09	1.81
2.1 - 4.0		0.26	0.28	0.43	0.27	0.56	0.38	0.67	0.45	0.41	0.27	0.63	0.63	0.58	0.43	0.51	0.38	7.13
4.1 - 6.0		0.21	0.19	0.37	0.69	0.58	0.55	0.65	0.64	0.65	0.80	0.92	0.74	0.86	0.84	0.57	0.37	9.64
6.1 - 8.0		0.01	0.01	0.09	0.06	0.03	0.05	0.10	0.03	0.08	0.15	0.14	0.13	0.14	0.08	0.03	0.02	1.16
8.1 - 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.00	0.03
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0 - 2.0	F (stable)	0.03	0.01	0.03	0.02	0.02	0.03	0.03	0.02	0.03	0.02	0.02	0.01	0.02	0.01	0.00	0.01	0.30
2.1 - 4.0		0.15	0.08	0.11	0.02	0.10	0.03	0.22	0.09	0.08	0.05	0.09	0.09	0.10	0.12	0.03	0.07	1.44
4.1 - 6.0		0.13	0.15	0.24	0.30	0.22	0.08	0.23	0.13	0.14	0.06	0.16	0.14	0.16	0.18	0.05	0.05	2.42
6.1 - 8.0		0.01	0.00	0.03	0.03	0.01	0.01	0.03	0.02	0.02	0.02	0.04	0.00	0.03	0.02	0.00	0.01	0.29
8.1 - 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0 - 2.0	G (very stable)	0.00	0.01	0.01	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.14
2.1 - 4.0		0.00	0.07	0.26	0.01	0.01	0.01	0.10	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.50
4.1 - 6.0		0.00	0.00	0.07	0.01	0.00	0.01	0.03	0.01	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.18
6.1 - 8.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
8.1 - 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
> 12.0		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
All classes	All classes	3.06	2.94	5.08	6.57	7.23	6.31	6.52	5.62	5.77	6.08	6.90	6.76	8.42	9.15	8.59	4.97	

Table B-2. Annual average meteorological dispersion/deposition parameters within 80 kilometers of SRP site center for elevated releases

Direction from site	Distance (km)									
	0-2	2-3	3-5	5-6	6-8	8-16	16-32	32-48	48-64	64-80
ANNUAL AVERAGE χ/Q , NO DECAY, UNDEPLETED (sec/m ³)										
N	1.657 x 10 ⁻⁷	9.830 x 10 ⁻⁸	6.035 x 10 ⁻⁸	4.110 x 10 ⁻⁸	3.030 x 10 ⁻⁸	1.617 x 10 ⁻⁸	6.688 x 10 ⁻⁹	3.455 x 10 ⁻⁹	2.246 x 10 ⁻⁹	1.630 x 10 ⁻⁹
NNE	1.715 x 10 ⁻⁷	9.824 x 10 ⁻⁸	5.792 x 10 ⁻⁸	3.855 x 10 ⁻⁸	2.800 x 10 ⁻⁸	1.461 x 10 ⁻⁸	5.878 x 10 ⁻⁹	2.997 x 10 ⁻⁹	1.938 x 10 ⁻⁹	1.402 x 10 ⁻⁹
NE	1.851 x 10 ⁻⁷	1.140 x 10 ⁻⁷	7.034 x 10 ⁻⁸	4.786 x 10 ⁻⁸	3.523 x 10 ⁻⁸	1.870 x 10 ⁻⁸	7.660 x 10 ⁻⁹	3.931 x 10 ⁻⁹	2.546 x 10 ⁻⁹	1.843 x 10 ⁻⁹
ENE	1.979 x 10 ⁻⁷	1.186 x 10 ⁻⁷	7.223 x 10 ⁻⁸	4.881 x 10 ⁻⁸	3.578 x 10 ⁻⁸	1.891 x 10 ⁻⁸	7.703 x 10 ⁻⁹	3.936 x 10 ⁻⁹	2.542 x 10 ⁻⁹	1.837 x 10 ⁻⁹
E	2.592 x 10 ⁻⁷	1.492 x 10 ⁻⁷	8.848 x 10 ⁻⁸	5.922 x 10 ⁻⁸	4.323 x 10 ⁻⁸	2.278 x 10 ⁻⁸	9.331 x 10 ⁻⁹	4.829 x 10 ⁻⁹	3.150 x 10 ⁻⁹	2.294 x 10 ⁻⁹
ESE	2.821 x 10 ⁻⁷	1.583 x 10 ⁻⁷	9.177 x 10 ⁻⁸	6.061 x 10 ⁻⁸	4.382 x 10 ⁻⁸	2.274 x 10 ⁻⁸	9.098 x 10 ⁻⁹	4.628 x 10 ⁻⁹	2.990 x 10 ⁻⁹	2.162 x 10 ⁻⁹
SE	2.365 x 10 ⁻⁷	1.357 x 10 ⁻⁷	7.860 x 10 ⁻⁸	5.161 x 10 ⁻⁸	3.711 x 10 ⁻⁸	1.904 x 10 ⁻⁸	7.490 x 10 ⁻⁹	3.757 x 10 ⁻⁹	2.407 x 10 ⁻⁹	1.731 x 10 ⁻⁹
SSE	1.609 x 10 ⁻⁷	8.715 x 10 ⁻⁸	5.018 x 10 ⁻⁸	3.311 x 10 ⁻⁸	2.394 x 10 ⁻⁸	1.246 x 10 ⁻⁸	5.017 x 10 ⁻⁹	2.571 x 10 ⁻⁹	1.669 x 10 ⁻⁹	1.212 x 10 ⁻⁹
S	9.942 x 10 ⁻⁸	5.287 x 10 ⁻⁸	3.174 x 10 ⁻⁸	2.172 x 10 ⁻⁸	1.615 x 10 ⁻⁸	8.804 x 10 ⁻⁹	3.772 x 10 ⁻⁹	2.007 x 10 ⁻⁹	1.329 x 10 ⁻⁹	9.773 x 10 ⁻¹⁰
SSW	9.513 x 10 ⁻⁸	5.374 x 10 ⁻⁸	3.282 x 10 ⁻⁸	2.247 x 10 ⁻⁸	1.669 x 10 ⁻⁸	9.063 x 10 ⁻⁹	3.867 x 10 ⁻⁹	2.055 x 10 ⁻⁹	1.360 x 10 ⁻⁹	1.000 x 10 ⁻⁹
SW	1.629 x 10 ⁻⁷	9.250 x 10 ⁻⁸	5.601 x 10 ⁻⁸	3.832 x 10 ⁻⁸	2.850 x 10 ⁻⁸	1.560 x 10 ⁻⁸	6.776 x 10 ⁻⁹	3.661 x 10 ⁻⁹	2.449 x 10 ⁻⁹	1.815 x 10 ⁻⁹
WSW	2.038 x 10 ⁻⁷	1.107 x 10 ⁻⁷	6.305 x 10 ⁻⁸	4.144 x 10 ⁻⁸	2.991 x 10 ⁻⁸	1.553 x 10 ⁻⁸	6.242 x 10 ⁻⁹	3.200 x 10 ⁻⁹	2.078 x 10 ⁻⁹	1.508 x 10 ⁻⁹
W	2.212 x 10 ⁻⁷	1.229 x 10 ⁻⁷	7.136 x 10 ⁻⁸	4.735 x 10 ⁻⁸	3.438 x 10 ⁻⁸	1.800 x 10 ⁻⁸	7.305 x 10 ⁻⁹	3.760 x 10 ⁻⁹	2.445 x 10 ⁻⁹	1.777 x 10 ⁻⁹
WNW	2.032 x 10 ⁻⁷	1.085 x 10 ⁻⁷	6.167 x 10 ⁻⁸	4.047 x 10 ⁻⁸	2.918 x 10 ⁻⁸	1.515 x 10 ⁻⁸	6.103 x 10 ⁻⁹	3.132 x 10 ⁻⁹	2.036 x 10 ⁻⁹	1.480 x 10 ⁻⁹
NW	1.796 x 10 ⁻⁷	1.080 x 10 ⁻⁷	6.754 x 10 ⁻⁸	4.674 x 10 ⁻⁸	3.492 x 10 ⁻⁸	1.911 x 10 ⁻⁸	8.213 x 10 ⁻⁹	4.375 x 10 ⁻⁹	2.897 x 10 ⁻⁹	2.131 x 10 ⁻⁹
NNW	1.648 x 10 ⁻⁷	9.680 x 10 ⁻⁸	5.825 x 10 ⁻⁸	3.922 x 10 ⁻⁸	2.870 x 10 ⁻⁸	1.513 x 10 ⁻⁸	6.167 x 10 ⁻⁹	3.163 x 10 ⁻⁹	2.049 x 10 ⁻⁹	1.485 x 10 ⁻⁹
ANNUAL AVERAGE χ/Q , DECAY, UNDEPLETED, SITE ANNUAL DECAYED χ/Q (sec/m ³)										
N	1.653 x 10 ⁻⁷	9.782 x 10 ⁻⁸	5.987 x 10 ⁻⁸	4.064 x 10 ⁻⁸	2.987 x 10 ⁻⁸	1.580 x 10 ⁻⁸	6.384 x 10 ⁻⁹	3.194 x 10 ⁻⁹	2.012 x 10 ⁻⁹	1.416 x 10 ⁻⁹
NNE	1.711 x 10 ⁻⁷	9.781 x 10 ⁻⁸	5.751 x 10 ⁻⁸	3.818 x 10 ⁻⁸	2.765 x 10 ⁻⁸	1.431 x 10 ⁻⁸	5.644 x 10 ⁻⁹	2.797 x 10 ⁻⁹	1.758 x 10 ⁻⁹	1.237 x 10 ⁻⁹
NE	1.846 x 10 ⁻⁷	1.135 x 10 ⁻⁷	6.986 x 10 ⁻⁸	4.741 x 10 ⁻⁸	3.481 x 10 ⁻⁸	1.833 x 10 ⁻⁸	7.366 x 10 ⁻⁹	3.679 x 10 ⁻⁹	2.319 x 10 ⁻⁹	1.634 x 10 ⁻⁹
ENE	1.974 x 10 ⁻⁷	1.181 x 10 ⁻⁷	7.168 x 10 ⁻⁸	4.831 x 10 ⁻⁸	3.530 x 10 ⁻⁸	1.850 x 10 ⁻⁸	7.377 x 10 ⁻⁹	3.658 x 10 ⁻⁹	2.294 x 10 ⁻⁹	1.610 x 10 ⁻⁹
E	2.586 x 10 ⁻⁷	1.484 x 10 ⁻⁷	8.779 x 10 ⁻⁸	5.858 x 10 ⁻⁸	4.263 x 10 ⁻⁸	2.227 x 10 ⁻⁸	8.914 x 10 ⁻⁹	4.466 x 10 ⁻⁹	2.822 x 10 ⁻⁹	1.990 x 10 ⁻⁹
ESE	2.813 x 10 ⁻⁷	1.575 x 10 ⁻⁷	9.108 x 10 ⁻⁸	5.998 x 10 ⁻⁸	4.324 x 10 ⁻⁸	2.225 x 10 ⁻⁸	8.716 x 10 ⁻⁹	4.304 x 10 ⁻⁹	2.700 x 10 ⁻⁹	1.896 x 10 ⁻⁹
SE	2.359 x 10 ⁻⁷	1.351 x 10 ⁻⁷	7.808 x 10 ⁻⁸	5.113 x 10 ⁻⁸	3.666 x 10 ⁻⁸	1.868 x 10 ⁻⁸	7.199 x 10 ⁻⁹	3.511 x 10 ⁻⁹	2.187 x 10 ⁻⁹	1.529 x 10 ⁻⁹
SSE	1.604 x 10 ⁻⁷	8.673 x 10 ⁻⁸	4.979 x 10 ⁻⁸	3.276 x 10 ⁻⁸	2.362 x 10 ⁻⁸	1.218 x 10 ⁻⁸	4.799 x 10 ⁻⁹	2.384 x 10 ⁻⁹	1.501 x 10 ⁻⁹	1.057 x 10 ⁻⁹
S	9.914 x 10 ⁻⁸	5.259 x 10 ⁻⁸	3.148 x 10 ⁻⁸	2.147 x 10 ⁻⁸	1.591 x 10 ⁻⁸	8.596 x 10 ⁻⁹	3.597 x 10 ⁻⁹	1.853 x 10 ⁻⁹	1.188 x 10 ⁻⁹	8.459 x 10 ⁻¹⁰
SSW	9.485 x 10 ⁻⁸	5.345 x 10 ⁻⁸	3.254 x 10 ⁻⁸	2.221 x 10 ⁻⁸	1.643 x 10 ⁻⁸	8.841 x 10 ⁻⁹	3.683 x 10 ⁻⁹	1.894 x 10 ⁻⁹	1.213 x 10 ⁻⁹	8.643 x 10 ⁻¹⁰
SW	1.624 x 10 ⁻⁷	9.201 x 10 ⁻⁸	5.553 x 10 ⁻⁸	3.787 x 10 ⁻⁸	2.807 x 10 ⁻⁸	1.523 x 10 ⁻⁸	6.462 x 10 ⁻⁹	3.384 x 10 ⁻⁹	2.195 x 10 ⁻⁹	1.578 x 10 ⁻⁹
WSW	2.033 x 10 ⁻⁷	1.103 x 10 ⁻⁷	6.261 x 10 ⁻⁸	4.105 x 10 ⁻⁸	2.955 x 10 ⁻⁸	1.523 x 10 ⁻⁸	6.004 x 10 ⁻⁹	2.997 x 10 ⁻⁹	1.895 x 10 ⁻⁹	1.340 x 10 ⁻⁹
W	2.207 x 10 ⁻⁷	1.224 x 10 ⁻⁷	7.087 x 10 ⁻⁸	4.690 x 10 ⁻⁸	3.397 x 10 ⁻⁸	1.765 x 10 ⁻⁸	7.021 x 10 ⁻⁹	3.515 x 10 ⁻⁹	2.225 x 10 ⁻⁹	1.573 x 10 ⁻⁹
WNW	2.027 x 10 ⁻⁷	1.080 x 10 ⁻⁷	6.124 x 10 ⁻⁸	4.008 x 10 ⁻⁸	2.882 x 10 ⁻⁸	1.485 x 10 ⁻⁸	5.856 x 10 ⁻⁹	2.918 x 10 ⁻⁹	1.843 x 10 ⁻⁹	1.301 x 10 ⁻⁹
NW	1.791 x 10 ⁻⁷	1.075 x 10 ⁻⁷	6.703 x 10 ⁻⁸	4.625 x 10 ⁻⁸	3.445 x 10 ⁻⁸	1.869 x 10 ⁻⁸	7.863 x 10 ⁻⁹	4.064 x 10 ⁻⁹	2.612 x 10 ⁻⁹	1.865 x 10 ⁻⁹
NNW	1.644 x 10 ⁻⁷	9.637 x 10 ⁻⁸	5.783 x 10 ⁻⁸	3.883 x 10 ⁻⁸	2.833 x 10 ⁻⁸	1.482 x 10 ⁻⁸	5.917 x 10 ⁻⁹	2.949 x 10 ⁻⁹	1.857 x 10 ⁻⁹	1.308 x 10 ⁻⁹

Table B-2. Annual average meteorological dispersion/deposition parameters within 80 kilometers of SRP site center for elevated releases (continued)

Direction from site	Distance (km)									
	0-2	2-3	3-5	5-6	6-8	8-16	16-32	32-48	48-64	64-80
ANNUAL AVERAGE χ/Q , DECAY, DEPLETED (sec/m ³)										
N	1.617 x 10 ⁻⁷	9.484 x 10 ⁻⁸	5.757 x 10 ⁻⁸	3.886 x 10 ⁻⁸	2.845 x 10 ⁻⁸	1.493 x 10 ⁻⁸	5.959 x 10 ⁻⁹	2.962 x 10 ⁻⁹	1.857 x 10 ⁻⁹	1.294 x 10 ⁻⁹
NNE	1.673 x 10 ⁻⁷	9.451 x 10 ⁻⁸	5.490 x 10 ⁻⁸	3.613 x 10 ⁻⁸	2.600 x 10 ⁻⁸	1.328 x 10 ⁻⁸	5.120 x 10 ⁻⁹	2.494 x 10 ⁻⁹	1.546 x 10 ⁻⁹	1.069 x 10 ⁻⁹
NE	1.807 x 10 ⁻⁷	1.100 x 10 ⁻⁷	6.711 x 10 ⁻⁸	4.524 x 10 ⁻⁸	3.305 x 10 ⁻⁸	1.724 x 10 ⁻⁸	6.824 x 10 ⁻⁹	3.375 x 10 ⁻⁹	2.112 x 10 ⁻⁹	1.472 x 10 ⁻⁹
ENE	1.931 x 10 ⁻⁷	1.145 x 10 ⁻⁷	6.882 x 10 ⁻⁸	4.606 x 10 ⁻⁸	3.349 x 10 ⁻⁸	1.738 x 10 ⁻⁸	6.820 x 10 ⁻⁹	3.348 x 10 ⁻⁹	2.084 x 10 ⁻⁹	1.446 x 10 ⁻⁹
E	2.528 x 10 ⁻⁷	1.435 x 10 ⁻⁷	8.396 x 10 ⁻⁸	5.561 x 10 ⁻⁸	4.024 x 10 ⁻⁸	2.080 x 10 ⁻⁸	8.195 x 10 ⁻⁹	4.068 x 10 ⁻⁹	2.554 x 10 ⁻⁹	1.783 x 10 ⁻⁹
ESE	2.750 x 10 ⁻⁷	1.520 x 10 ⁻⁷	8.673 x 10 ⁻⁸	5.655 x 10 ⁻⁸	4.046 x 10 ⁻⁸	2.051 x 10 ⁻⁸	7.833 x 10 ⁻⁹	3.791 x 10 ⁻⁹	2.342 x 10 ⁻⁹	1.615 x 10 ⁻⁹
SE	2.308 x 10 ⁻⁷	1.304 x 10 ⁻⁷	7.426 x 10 ⁻⁸	4.809 x 10 ⁻⁸	3.418 x 10 ⁻⁸	1.711 x 10 ⁻⁸	6.395 x 10 ⁻⁹	3.040 x 10 ⁻⁹	1.857 x 10 ⁻⁹	1.270 x 10 ⁻⁹
SSE	1.567 x 10 ⁻⁷	8.367 x 10 ⁻⁸	4.746 x 10 ⁻⁸	3.095 x 10 ⁻⁸	2.217 x 10 ⁻⁸	1.129 x 10 ⁻⁸	4.344 x 10 ⁻⁹	2.119 x 10 ⁻⁹	1.314 x 10 ⁻⁹	9.085 x 10 ⁻¹⁰
S	9.680 x 10 ⁻⁸	5.077 x 10 ⁻⁸	3.010 x 10 ⁻⁸	2.041 x 10 ⁻⁸	1.506 x 10 ⁻⁸	8.068 x 10 ⁻⁹	3.330 x 10 ⁻⁹	1.702 x 10 ⁻⁹	1.084 x 10 ⁻⁹	7.636 x 10 ⁻¹⁰
SSW	9.270 x 10 ⁻⁸	5.176 x 10 ⁻⁸	3.126 x 10 ⁻⁸	2.122 x 10 ⁻⁸	1.565 x 10 ⁻⁸	8.362 x 10 ⁻⁹	3.450 x 10 ⁻⁹	1.767 x 10 ⁻⁹	1.130 x 10 ⁻⁹	7.988 x 10 ⁻¹⁰
SW	1.587 x 10 ⁻⁷	8.906 x 10 ⁻⁸	5.332 x 10 ⁻⁸	3.619 x 10 ⁻⁸	2.674 x 10 ⁻⁸	1.444 x 10 ⁻⁸	6.092 x 10 ⁻⁹	3.193 x 10 ⁻⁹	2.075 x 10 ⁻⁹	1.487 x 10 ⁻⁹
WSW	1.985 x 10 ⁻⁷	1.062 x 10 ⁻⁷	5.949 x 10 ⁻⁸	3.862 x 10 ⁻⁸	2.760 x 10 ⁻⁸	1.402 x 10 ⁻⁸	5.392 x 10 ⁻⁹	2.638 x 10 ⁻⁹	1.642 x 10 ⁻⁹	1.139 x 10 ⁻⁹
W	2.156 x 10 ⁻⁷	1.181 x 10 ⁻⁷	6.755 x 10 ⁻⁸	4.433 x 10 ⁻⁸	3.190 x 10 ⁻⁸	1.637 x 10 ⁻⁸	6.379 x 10 ⁻⁹	3.144 x 10 ⁻⁹	1.965 x 10 ⁻⁹	1.368 x 10 ⁻⁹
WNW	1.980 x 10 ⁻⁷	1.041 x 10 ⁻⁷	5.819 x 10 ⁻⁸	3.770 x 10 ⁻⁸	2.690 x 10 ⁻⁸	1.365 x 10 ⁻⁸	5.239 x 10 ⁻⁹	2.555 x 10 ⁻⁹	1.585 x 10 ⁻⁹	1.096 x 10 ⁻⁹
NW	1.752 x 10 ⁻⁷	1.042 x 10 ⁻⁷	6.453 x 10 ⁻⁸	4.431 x 10 ⁻⁸	3.290 x 10 ⁻⁸	1.775 x 10 ⁻⁸	7.415 x 10 ⁻⁹	3.830 x 10 ⁻⁹	2.463 x 10 ⁻⁹	1.751 x 10 ⁻⁹
NNW	1.608 x 10 ⁻⁷	9.323 x 10 ⁻⁸	5.532 x 10 ⁻⁸	3.684 x 10 ⁻⁸	2.673 x 10 ⁻⁸	1.382 x 10 ⁻⁸	5.410 x 10 ⁻⁹	2.659 x 10 ⁻⁹	1.658 x 10 ⁻⁹	1.151 x 10 ⁻⁹
ANNUAL AVERAGE D/Q (m ⁻²)										
N	2.473 x 10 ⁻⁹	9.109 x 10 ⁻¹⁰	4.045 x 10 ⁻¹⁰	2.331 x 10 ⁻¹⁰	1.539 x 10 ⁻¹⁰	6.845 x 10 ⁻¹¹	2.264 x 10 ⁻¹¹	1.049 x 10 ⁻¹¹	6.614 x 10 ⁻¹²	4.729 x 10 ⁻¹²
NNE	2.697 x 10 ⁻⁹	1.011 x 10 ⁻⁹	4.511 x 10 ⁻¹⁰	2.602 x 10 ⁻¹⁰	1.717 x 10 ⁻¹⁰	7.626 x 10 ⁻¹¹	2.506 x 10 ⁻¹¹	1.151 x 10 ⁻¹¹	7.194 x 10 ⁻¹²	5.100 x 10 ⁻¹²
NE	2.740 x 10 ⁻⁹	1.038 x 10 ⁻⁹	4.647 x 10 ⁻¹⁰	2.682 x 10 ⁻¹⁰	1.770 x 10 ⁻¹⁰	7.851 x 10 ⁻¹¹	2.569 x 10 ⁻¹¹	1.179 x 10 ⁻¹¹	7.421 x 10 ⁻¹²	5.323 x 10 ⁻¹²
ENE	2.811 x 10 ⁻⁹	1.059 x 10 ⁻⁹	4.737 x 10 ⁻¹⁰	2.733 x 10 ⁻¹⁰	1.804 x 10 ⁻¹⁰	8.005 x 10 ⁻¹¹	2.625 x 10 ⁻¹¹	1.205 x 10 ⁻¹¹	7.565 x 10 ⁻¹²	5.399 x 10 ⁻¹²
E	3.650 x 10 ⁻⁹	1.369 x 10 ⁻⁹	6.114 x 10 ⁻¹⁰	3.527 x 10 ⁻¹⁰	2.327 x 10 ⁻¹⁰	1.033 x 10 ⁻¹⁰	3.394 x 10 ⁻¹¹	1.559 x 10 ⁻¹¹	9.764 x 10 ⁻¹²	6.939 x 10 ⁻¹²
ESE	4.124 x 10 ⁻⁹	1.582 x 10 ⁻⁹	7.110 x 10 ⁻¹⁰	4.104 x 10 ⁻¹⁰	2.708 x 10 ⁻¹⁰	1.200 x 10 ⁻¹⁰	3.908 x 10 ⁻¹¹	1.776 x 10 ⁻¹¹	1.100 x 10 ⁻¹¹	7.739 x 10 ⁻¹²
SE	4.028 x 10 ⁻⁹	1.575 x 10 ⁻⁹	7.119 x 10 ⁻¹⁰	4.113 x 10 ⁻¹⁰	2.714 x 10 ⁻¹⁰	1.200 x 10 ⁻¹⁰	3.880 x 10 ⁻¹¹	1.747 x 10 ⁻¹¹	1.072 x 10 ⁻¹¹	7.461 x 10 ⁻¹²
SSE	2.366 x 10 ⁻⁹	8.707 x 10 ⁻¹⁰	3.865 x 10 ⁻¹⁰	2.228 x 10 ⁻¹⁰	1.470 x 10 ⁻¹⁰	6.541 x 10 ⁻¹¹	2.164 x 10 ⁻¹¹	9.996 x 10 ⁻¹²	6.248 x 10 ⁻¹²	4.412 x 10 ⁻¹²
S	1.385 x 10 ⁻⁹	4.897 x 10 ⁻¹⁰	2.146 x 10 ⁻¹⁰	1.235 x 10 ⁻¹⁰	8.152 x 10 ⁻¹¹	3.642 x 10 ⁻¹¹	1.224 x 10 ⁻¹¹	5.765 x 10 ⁻¹²	3.666 x 10 ⁻¹²	2.631 x 10 ⁻¹²
SSW	1.251 x 10 ⁻⁹	4.481 x 10 ⁻¹⁰	1.972 x 10 ⁻¹⁰	1.136 x 10 ⁻¹⁰	7.496 x 10 ⁻¹¹	3.344 x 10 ⁻¹¹	1.118 x 10 ⁻¹¹	5.246 x 10 ⁻¹²	3.340 x 10 ⁻¹²	2.407 x 10 ⁻¹²
SW	1.979 x 10 ⁻⁹	7.211 x 10 ⁻¹⁰	3.191 x 10 ⁻¹⁰	1.839 x 10 ⁻¹⁰	1.213 x 10 ⁻¹⁰	5.404 x 10 ⁻¹¹	1.796 x 10 ⁻¹¹	8.384 x 10 ⁻¹²	5.355 x 10 ⁻¹²	3.888 x 10 ⁻¹²
WSW	3.024 x 10 ⁻⁹	1.120 x 10 ⁻⁹	4.979 x 10 ⁻¹⁰	2.870 x 10 ⁻¹⁰	1.894 x 10 ⁻¹⁰	8.423 x 10 ⁻¹¹	2.780 x 10 ⁻¹¹	1.282 x 10 ⁻¹¹	8.021 x 10 ⁻¹²	5.678 x 10 ⁻¹²
W	3.342 x 10 ⁻⁹	1.228 x 10 ⁻⁹	5.447 x 10 ⁻¹⁰	3.139 x 10 ⁻¹⁰	2.072 x 10 ⁻¹⁰	9.220 x 10 ⁻¹¹	3.052 x 10 ⁻¹¹	1.412 x 10 ⁻¹¹	8.852 x 10 ⁻¹²	6.275 x 10 ⁻¹²
WNW	3.053 x 10 ⁻⁹	1.120 x 10 ⁻⁹	4.969 x 10 ⁻¹⁰	2.864 x 10 ⁻¹⁰	1.890 x 10 ⁻¹⁰	8.411 x 10 ⁻¹¹	2.785 x 10 ⁻¹¹	1.288 x 10 ⁻¹¹	8.043 x 10 ⁻¹²	5.673 x 10 ⁻¹²
NW	2.555 x 10 ⁻⁹	9.364 x 10 ⁻¹⁰	4.152 x 10 ⁻¹⁰	2.393 x 10 ⁻¹⁰	1.579 x 10 ⁻¹⁰	7.028 x 10 ⁻¹¹	2.330 x 10 ⁻¹¹	1.085 x 10 ⁻¹¹	6.912 x 10 ⁻¹²	5.008 x 10 ⁻¹²
NNW	2.415 x 10 ⁻⁹	9.062 x 10 ⁻¹⁰	4.047 x 10 ⁻¹⁰	2.334 x 10 ⁻¹⁰	1.540 x 10 ⁻¹⁰	6.840 x 10 ⁻¹¹	2.246 x 10 ⁻¹¹	1.032 x 10 ⁻¹¹	6.468 x 10 ⁻¹²	4.602 x 10 ⁻¹²

Table B-3. Annual average meteorological dispersion/deposition parameters within 80 kilometers of SRP site center for ground-level releases

Direction from site	Distance (km)									
	0-2	2-3	3-5	5-6	6-8	8-16	16-32	32-48	48-64	64-80
ANNUAL AVERAGE χ/Q , NO DECAY, UNDEPLETED (sec/m^3)										
N	8.254×10^{-7}	2.524×10^{-7}	1.084×10^{-7}	6.403×10^{-8}	4.365×10^{-8}	2.117×10^{-8}	7.908×10^{-9}	3.881×10^{-9}	2.468×10^{-9}	1.769×10^{-9}
NNE	7.390×10^{-7}	2.245×10^{-7}	9.554×10^{-8}	5.606×10^{-8}	3.802×10^{-8}	1.827×10^{-8}	6.741×10^{-9}	3.291×10^{-9}	2.089×10^{-9}	1.495×10^{-9}
NE	9.494×10^{-7}	2.912×10^{-7}	1.251×10^{-7}	7.389×10^{-8}	5.035×10^{-8}	2.434×10^{-8}	9.042×10^{-9}	4.417×10^{-9}	2.800×10^{-9}	2.002×10^{-9}
ENE	9.499×10^{-7}	2.902×10^{-7}	1.241×10^{-7}	7.304×10^{-8}	4.966×10^{-8}	2.397×10^{-8}	8.882×10^{-9}	4.330×10^{-9}	2.742×10^{-9}	1.959×10^{-9}
E	1.227×10^{-6}	3.746×10^{-7}	1.605×10^{-7}	9.473×10^{-8}	6.453×10^{-8}	3.125×10^{-8}	1.167×10^{-8}	5.747×10^{-9}	3.666×10^{-9}	2.634×10^{-9}
ESE	1.156×10^{-6}	3.503×10^{-7}	1.486×10^{-7}	8.699×10^{-8}	5.889×10^{-8}	2.824×10^{-8}	1.039×10^{-8}	5.068×10^{-9}	3.216×10^{-9}	2.302×10^{-9}
SE	9.465×10^{-7}	2.866×10^{-7}	1.213×10^{-7}	7.079×10^{-8}	4.781×10^{-8}	2.282×10^{-8}	8.327×10^{-9}	4.029×10^{-9}	2.544×10^{-9}	1.814×10^{-9}
SSE	6.359×10^{-7}	1.918×10^{-7}	8.127×10^{-8}	4.757×10^{-8}	3.221×10^{-8}	1.548×10^{-8}	5.727×10^{-9}	2.813×10^{-9}	1.793×10^{-9}	1.288×10^{-9}
S	4.705×10^{-7}	1.433×10^{-7}	6.196×10^{-8}	3.681×10^{-8}	2.522×10^{-8}	1.236×10^{-8}	4.709×10^{-9}	2.353×10^{-9}	1.515×10^{-9}	1.095×10^{-9}
SSW	5.057×10^{-7}	1.551×10^{-7}	6.730×10^{-8}	4.009×10^{-8}	2.752×10^{-8}	1.351×10^{-8}	5.156×10^{-9}	2.576×10^{-9}	1.656×10^{-9}	1.197×10^{-9}
SW	9.776×10^{-7}	3.013×10^{-7}	1.313×10^{-7}	7.850×10^{-8}	5.404×10^{-8}	2.666×10^{-8}	1.025×10^{-8}	5.149×10^{-9}	3.322×10^{-9}	2.407×10^{-9}
WSW	8.207×10^{-7}	2.479×10^{-7}	1.048×10^{-7}	6.127×10^{-8}	4.144×10^{-8}	1.984×10^{-8}	7.307×10^{-9}	3.576×10^{-9}	2.276×10^{-9}	1.632×10^{-9}
W	9.536×10^{-7}	2.893×10^{-7}	1.230×10^{-7}	7.213×10^{-8}	4.892×10^{-8}	2.354×10^{-8}	8.718×10^{-9}	4.276×10^{-9}	2.722×10^{-9}	1.953×10^{-9}
WNW	7.890×10^{-7}	2.378×10^{-7}	1.007×10^{-7}	5.889×10^{-8}	3.987×10^{-8}	1.917×10^{-8}	7.106×10^{-9}	3.494×10^{-9}	2.229×10^{-9}	1.603×10^{-9}
NW	1.103×10^{-6}	3.407×10^{-7}	1.484×10^{-7}	8.866×10^{-8}	6.096×10^{-8}	2.997×10^{-8}	1.144×10^{-8}	5.699×10^{-9}	3.657×10^{-9}	2.638×10^{-9}
NNW	7.672×10^{-7}	2.342×10^{-7}	1.003×10^{-7}	5.907×10^{-8}	4.019×10^{-8}	1.939×10^{-8}	7.193×10^{-9}	3.517×10^{-9}	2.233×10^{-9}	1.598×10^{-9}
ANNUAL AVERAGE χ/Q , DECAY, UNDEPLETED, SITE ANNUAL DECAYED χ/Q (sec/m^3)										
N	8.235×10^{-7}	2.513×10^{-7}	1.076×10^{-7}	6.334×10^{-8}	4.304×10^{-8}	2.070×10^{-8}	7.557×10^{-9}	3.592×10^{-9}	2.214×10^{-9}	1.538×10^{-9}
NNE	7.375×10^{-7}	2.236×10^{-7}	9.490×10^{-8}	5.553×10^{-8}	3.756×10^{-8}	1.791×10^{-8}	6.477×10^{-9}	3.073×10^{-9}	1.896×10^{-9}	1.320×10^{-9}
NE	9.476×10^{-7}	2.901×10^{-7}	1.243×10^{-7}	7.322×10^{-8}	4.976×10^{-8}	2.388×10^{-8}	8.701×10^{-9}	4.135×10^{-9}	2.552×10^{-9}	1.776×10^{-9}
ENE	9.479×10^{-7}	2.890×10^{-7}	1.232×10^{-7}	7.231×10^{-8}	4.902×10^{-8}	2.347×10^{-8}	8.514×10^{-9}	4.028×10^{-9}	2.477×10^{-9}	1.719×10^{-9}
E	1.224×10^{-6}	3.729×10^{-7}	1.593×10^{-7}	9.367×10^{-8}	6.361×10^{-8}	3.052×10^{-8}	1.113×10^{-8}	5.297×10^{-9}	3.268×10^{-9}	2.271×10^{-9}
ESE	1.154×10^{-6}	3.488×10^{-7}	1.476×10^{-7}	8.613×10^{-8}	5.815×10^{-8}	2.766×10^{-8}	9.970×10^{-9}	4.721×10^{-9}	2.909×10^{-9}	2.023×10^{-9}
SE	9.447×10^{-7}	2.856×10^{-7}	1.205×10^{-7}	7.014×10^{-8}	4.725×10^{-8}	2.238×10^{-8}	8.005×10^{-9}	3.764×10^{-9}	2.310×10^{-9}	1.602×10^{-9}
SSE	6.345×10^{-7}	1.910×10^{-7}	8.068×10^{-8}	4.708×10^{-8}	3.179×10^{-8}	1.515×10^{-8}	5.484×10^{-9}	2.611×10^{-9}	1.615×10^{-9}	1.125×10^{-9}
S	4.694×10^{-7}	1.427×10^{-7}	6.148×10^{-8}	3.641×10^{-8}	2.487×10^{-8}	1.208×10^{-8}	4.497×10^{-9}	2.175×10^{-9}	1.355×10^{-9}	9.491×10^{-10}
SSW	5.045×10^{-7}	1.544×10^{-7}	6.677×10^{-8}	3.965×10^{-8}	2.713×10^{-8}	1.321×10^{-8}	4.925×10^{-9}	2.382×10^{-9}	1.484×10^{-9}	1.039×10^{-9}
SW	9.755×10^{-7}	2.999×10^{-7}	1.303×10^{-7}	7.768×10^{-8}	5.332×10^{-8}	2.609×10^{-8}	9.816×10^{-9}	4.786×10^{-9}	2.999×10^{-9}	2.110×10^{-9}
WSW	8.191×10^{-7}	2.470×10^{-7}	1.042×10^{-7}	6.072×10^{-8}	4.096×10^{-8}	1.948×10^{-8}	7.038×10^{-9}	3.355×10^{-9}	2.080×10^{-9}	1.454×10^{-9}
W	9.518×10^{-7}	2.882×10^{-7}	1.221×10^{-7}	7.145×10^{-8}	4.833×10^{-8}	2.308×10^{-8}	8.379×10^{-9}	3.996×10^{-9}	2.475×10^{-9}	1.727×10^{-9}
WNW	7.874×10^{-7}	2.368×10^{-7}	9.997×10^{-8}	5.832×10^{-8}	3.937×10^{-8}	1.879×10^{-8}	6.819×10^{-9}	3.255×10^{-9}	2.017×10^{-9}	1.408×10^{-9}
NW	1.101×10^{-6}	3.392×10^{-7}	1.474×10^{-7}	8.774×10^{-8}	6.015×10^{-8}	2.932×10^{-8}	1.094×10^{-8}	5.287×10^{-9}	3.291×10^{-9}	2.303×10^{-9}
NNW	7.657×10^{-7}	2.332×10^{-7}	9.959×10^{-8}	5.851×10^{-8}	3.969×10^{-8}	1.901×10^{-8}	6.910×10^{-9}	3.283×10^{-9}	2.027×10^{-9}	1.411×10^{-9}

Table B-3. Annual average meteorological dispersion/deposition parameters within 80 kilometers of SRP site center for ground-level releases (continued)

Direction from site	Distance (km)									
	0-2	2-3	3-5	5-6	6-8	8-16	16-32	32-48	48-64	64-80
ANNUAL AVERAGE χ/Q , DECA, DEPLETED (sec/m ³)										
N	7.396 x 10 ⁻⁷	2.154 x 10 ⁻⁷	8.784 x 10 ⁻⁸	4.988 x 10 ⁻⁸	3.290 x 10 ⁻⁸	1.496 x 10 ⁻⁸	4.918 x 10 ⁻⁹	2.112 x 10 ⁻⁹	1.212 x 10 ⁻⁹	7.949 x 10 ⁻¹⁰
NNE	6.623 x 10 ⁻⁷	1.916 x 10 ⁻⁷	7.745 x 10 ⁻⁸	4.369 x 10 ⁻⁸	2.868 x 10 ⁻⁸	1.293 x 10 ⁻⁸	4.200 x 10 ⁻⁹	1.795 x 10 ⁻⁹	1.029 x 10 ⁻⁹	6.749 x 10 ⁻¹⁰
NE	8.508 x 10 ⁻⁷	2.485 x 10 ⁻⁷	1.014 x 10 ⁻⁷	5.759 x 10 ⁻⁸	3.798 x 10 ⁻⁸	1.723 x 10 ⁻⁸	5.635 x 10 ⁻⁹	2.411 x 10 ⁻⁹	1.381 x 10 ⁻⁹	9.050 x 10 ⁻¹⁰
ENE	8.512 x 10 ⁻⁷	2.476 x 10 ⁻⁷	1.006 x 10 ⁻⁷	5.692 x 10 ⁻⁸	3.744 x 10 ⁻⁸	1.695 x 10 ⁻⁸	5.530 x 10 ⁻⁹	2.360 x 10 ⁻⁹	1.349 x 10 ⁻⁹	8.827 x 10 ⁻¹⁰
E	1.100 x 10 ⁻⁶	3.196 x 10 ⁻⁷	1.301 x 10 ⁻⁷	7.379 x 10 ⁻⁸	4.864 x 10 ⁻⁸	2.208 x 10 ⁻⁸	7.253 x 10 ⁻⁹	3.124 x 10 ⁻⁹	1.796 x 10 ⁻⁹	1.181 x 10 ⁻⁹
ESE	1.036 x 10 ⁻⁶	2.990 x 10 ⁻⁷	1.204 x 10 ⁻⁷	6.779 x 10 ⁻⁸	4.441 x 10 ⁻⁸	1.997 x 10 ⁻⁸	6.472 x 10 ⁻⁹	2.763 x 10 ⁻⁹	1.583 x 10 ⁻⁹	1.038 x 10 ⁻⁹
SE	8.483 x 10 ⁻⁷	2.447 x 10 ⁻⁷	9.830 x 10 ⁻⁸	5.518 x 10 ⁻⁸	3.607 x 10 ⁻⁸	1.615 x 10 ⁻⁸	5.190 x 10 ⁻⁹	2.199 x 10 ⁻⁹	1.253 x 10 ⁻⁹	8.190 x 10 ⁻¹⁰
SSE	5.699 x 10 ⁻⁷	1.637 x 10 ⁻⁷	6.587 x 10 ⁻⁸	3.706 x 10 ⁻⁸	2.429 x 10 ⁻⁸	1.094 x 10 ⁻⁸	3.564 x 10 ⁻⁹	1.532 x 10 ⁻⁹	8.813 x 10 ⁻¹⁰	5.798 x 10 ⁻¹⁰
S	4.216 x 10 ⁻⁷	1.223 x 10 ⁻⁷	5.021 x 10 ⁻⁸	2.868 x 10 ⁻⁸	1.901 x 10 ⁻⁸	8.734 x 10 ⁻⁹	2.926 x 10 ⁻⁹	1.280 x 10 ⁻⁹	7.429 x 10 ⁻¹⁰	4.918 x 10 ⁻¹⁰
SSW	4.532 x 10 ⁻⁷	1.323 x 10 ⁻⁷	5.453 x 10 ⁻⁸	3.123 x 10 ⁻⁸	2.074 x 10 ⁻⁸	9.548 x 10 ⁻⁹	3.205 x 10 ⁻⁹	1.401 x 10 ⁻⁹	8.128 x 10 ⁻¹⁰	5.378 x 10 ⁻¹⁰
SW	8.761 x 10 ⁻⁷	2.570 x 10 ⁻⁷	1.064 x 10 ⁻⁷	6.115 x 10 ⁻⁸	4.074 x 10 ⁻⁸	1.884 x 10 ⁻⁸	6.374 x 10 ⁻⁹	2.805 x 10 ⁻⁹	1.634 x 10 ⁻⁹	1.084 x 10 ⁻⁹
WSW	7.355 x 10 ⁻⁷	2.116 x 10 ⁻⁷	8.499 x 10 ⁻⁸	4.776 x 10 ⁻⁸	3.126 x 10 ⁻⁸	1.405 x 10 ⁻⁸	4.555 x 10 ⁻⁹	1.953 x 10 ⁻⁹	1.123 x 10 ⁻⁹	7.387 x 10 ⁻¹⁰
W	8.547 x 10 ⁻⁷	2.469 x 10 ⁻⁷	9.967 x 10 ⁻⁸	5.621 x 10 ⁻⁸	3.690 x 10 ⁻⁸	1.665 x 10 ⁻⁸	5.431 x 10 ⁻⁹	2.333 x 10 ⁻⁹	1.341 x 10 ⁻⁹	8.821 x 10 ⁻¹⁰
WNW	7.071 x 10 ⁻⁷	2.030 x 10 ⁻⁷	8.159 x 10 ⁻⁸	4.589 x 10 ⁻⁸	3.007 x 10 ⁻⁸	1.356 x 10 ⁻⁸	4.425 x 10 ⁻⁹	1.905 x 10 ⁻⁹	1.097 x 10 ⁻⁹	7.225 x 10 ⁻¹⁰
NW	9.889 x 10 ⁻⁷	2.907 x 10 ⁻⁷	1.203 x 10 ⁻⁷	6.907 x 10 ⁻⁸	4.596 x 10 ⁻⁸	2.118 x 10 ⁻⁸	7.111 x 10 ⁻⁹	3.103 x 10 ⁻⁹	1.797 x 10 ⁻⁹	1.187 x 10 ⁻⁹
NNW	6.876 x 10 ⁻⁷	1.999 x 10 ⁻⁷	8.127 x 10 ⁻⁸	4.604 x 10 ⁻⁸	3.031 x 10 ⁻⁸	1.372 x 10 ⁻⁸	4.481 x 10 ⁻⁹	1.919 x 10 ⁻⁹	1.100 x 10 ⁻⁹	7.215 x 10 ⁻¹⁰
ANNUAL AVERAGE D/Q (m ⁻²)										
N	6.024 x 10 ⁻⁹	1.861 x 10 ⁻⁹	7.406 x 10 ⁻¹⁰	4.047 x 10 ⁻¹⁰	2.572 x 10 ⁻¹⁰	1.105 x 10 ⁻¹⁰	3.426 x 10 ⁻¹¹	1.358 x 10 ⁻¹¹	7.251 x 10 ⁻¹²	4.488 x 10 ⁻¹²
NNE	6.351 x 10 ⁻⁹	1.962 x 10 ⁻⁹	7.808 x 10 ⁻¹⁰	4.267 x 10 ⁻¹⁰	2.712 x 10 ⁻¹⁰	1.165 x 10 ⁻¹⁰	3.612 x 10 ⁻¹¹	1.432 x 10 ⁻¹¹	7.645 x 10 ⁻¹²	4.732 x 10 ⁻¹²
NE	7.209 x 10 ⁻⁹	2.227 x 10 ⁻⁹	8.863 x 10 ⁻¹⁰	4.843 x 10 ⁻¹⁰	3.078 x 10 ⁻¹⁰	1.322 x 10 ⁻¹⁰	4.100 x 10 ⁻¹¹	1.625 x 10 ⁻¹¹	8.678 x 10 ⁻¹²	5.371 x 10 ⁻¹²
ENE	7.064 x 10 ⁻⁹	2.182 x 10 ⁻⁹	8.684 x 10 ⁻¹⁰	4.746 x 10 ⁻¹⁰	3.016 x 10 ⁻¹⁰	1.296 x 10 ⁻¹⁰	4.017 x 10 ⁻¹¹	1.592 x 10 ⁻¹¹	8.503 x 10 ⁻¹²	5.263 x 10 ⁻¹²
E	8.791 x 10 ⁻⁹	2.716 x 10 ⁻⁹	1.081 x 10 ⁻⁹	5.906 x 10 ⁻¹⁰	3.754 x 10 ⁻¹⁰	1.612 x 10 ⁻¹⁰	5.000 x 10 ⁻¹¹	1.982 x 10 ⁻¹¹	1.058 x 10 ⁻¹¹	6.550 x 10 ⁻¹²
ESE	9.561 x 10 ⁻⁹	2.954 x 10 ⁻⁹	1.175 x 10 ⁻⁹	6.423 x 10 ⁻¹⁰	4.083 x 10 ⁻¹⁰	1.754 x 10 ⁻¹⁰	5.438 x 10 ⁻¹¹	2.155 x 10 ⁻¹¹	1.151 x 10 ⁻¹¹	7.124 x 10 ⁻¹²
SE	8.976 x 10 ⁻⁹	2.773 x 10 ⁻⁹	1.104 x 10 ⁻⁹	6.030 x 10 ⁻¹⁰	3.833 x 10 ⁻¹⁰	1.646 x 10 ⁻¹⁰	5.105 x 10 ⁻¹¹	2.023 x 10 ⁻¹¹	1.080 x 10 ⁻¹¹	6.688 x 10 ⁻¹²
SSE	5.195 x 10 ⁻⁹	1.605 x 10 ⁻⁹	6.387 x 10 ⁻¹⁰	3.490 x 10 ⁻¹⁰	2.218 x 10 ⁻¹⁰	9.528 x 10 ⁻¹¹	2.955 x 10 ⁻¹¹	1.171 x 10 ⁻¹¹	6.254 x 10 ⁻¹²	3.871 x 10 ⁻¹²
S	3.199 x 10 ⁻⁹	9.884 x 10 ⁻¹⁰	3.933 x 10 ⁻¹⁰	2.149 x 10 ⁻¹⁰	1.366 x 10 ⁻¹⁰	5.868 x 10 ⁻¹¹	1.820 x 10 ⁻¹¹	7.212 x 10 ⁻¹²	3.851 x 10 ⁻¹²	2.384 x 10 ⁻¹²
SSW	3.072 x 10 ⁻⁹	9.491 x 10 ⁻¹⁰	3.777 x 10 ⁻¹⁰	2.064 x 10 ⁻¹⁰	1.312 x 10 ⁻¹⁰	5.634 x 10 ⁻¹¹	1.747 x 10 ⁻¹¹	6.925 x 10 ⁻¹²	3.698 x 10 ⁻¹²	2.289 x 10 ⁻¹²
SW	5.308 x 10 ⁻⁹	1.640 x 10 ⁻⁹	6.525 x 10 ⁻¹⁰	3.566 x 10 ⁻¹⁰	2.266 x 10 ⁻¹⁰	9.735 x 10 ⁻¹¹	3.019 x 10 ⁻¹¹	1.196 x 10 ⁻¹¹	6.389 x 10 ⁻¹²	3.955 x 10 ⁻¹²
WSW	6.867 x 10 ⁻⁹	2.122 x 10 ⁻⁹	8.443 x 10 ⁻¹⁰	4.614 x 10 ⁻¹⁰	2.932 x 10 ⁻¹⁰	1.260 x 10 ⁻¹⁰	3.906 x 10 ⁻¹¹	1.548 x 10 ⁻¹¹	8.267 x 10 ⁻¹²	5.117 x 10 ⁻¹²
W	7.555 x 10 ⁻⁹	2.334 x 10 ⁻⁹	9.288 x 10 ⁻¹⁰	5.075 x 10 ⁻¹⁰	3.226 x 10 ⁻¹⁰	1.386 x 10 ⁻¹⁰	4.297 x 10 ⁻¹¹	1.703 x 10 ⁻¹¹	9.094 x 10 ⁻¹²	5.629 x 10 ⁻¹²
WNW	6.595 x 10 ⁻⁹	2.037 x 10 ⁻⁹	8.108 x 10 ⁻¹⁰	4.430 x 10 ⁻¹⁰	2.816 x 10 ⁻¹⁰	1.210 x 10 ⁻¹⁰	3.751 x 10 ⁻¹¹	1.487 x 10 ⁻¹¹	7.938 x 10 ⁻¹²	4.914 x 10 ⁻¹²
NW	6.813 x 10 ⁻⁹	2.105 x 10 ⁻⁹	8.376 x 10 ⁻¹⁰	4.577 x 10 ⁻¹⁰	2.909 x 10 ⁻¹⁰	1.250 x 10 ⁻¹⁰	3.875 x 10 ⁻¹¹	1.536 x 10 ⁻¹¹	8.201 x 10 ⁻¹²	5.076 x 10 ⁻¹²
NNW	5.875 x 10 ⁻⁹	1.815 x 10 ⁻⁹	7.223 x 10 ⁻¹⁰	3.947 x 10 ⁻¹⁰	2.509 x 10 ⁻¹⁰	1.078 x 10 ⁻¹⁰	3.341 x 10 ⁻¹¹	1.324 x 10 ⁻¹¹	7.072 x 10 ⁻¹²	4.377 x 10 ⁻¹²

Table B-4. Population and annual food production within 80 kilometers of the SRP site center^a

Direction	Distance (km)						
	0-8	8-16	16-32	32-48	48-64	64-80	0-80
POPULATION							
N	0	2.34×10^3	3.97×10^3	3.41×10^3	1.04×10^4	3.38×10^4	5.39×10^4
NNE	0	--	1.02×10^3	3.80×10^3	4.96×10^3	2.45×10^4	3.42×10^4
NE	0	--	1.30×10^3	5.79×10^3	9.53×10^3	2.01×10^4	3.68×10^4
ENE	0	--	6.91×10^3	2.35×10^3	9.33×10^3	5.23×10^4	7.09×10^4
E	0	--	3.56×10^3	1.43×10^4	7.17×10^3	8.91×10^3	3.39×10^4
ESE	0	--	7.14×10^3	3.89×10^3	3.21×10^3	5.02×10^3	1.93×10^4
SE	0	--	--	7.14×10^3	5.98×10^3	1.11×10^4	2.42×10^4
SSE	0	--	7.23×10^2	7.65×10^2	5.66×10^2	7.05×10^3	9.10×10^3
S	0	--	1.02×10^3	3.01×10^3	7.80×10^3	4.92×10^3	1.67×10^4
SSW	0	--	2.87×10^2	2.44×10^3	7.03×10^3	3.08×10^3	1.28×10^4
SW	0	--	1.04×10^3	2.95×10^3	2.07×10^3	2.50×10^3	8.56×10^3
WSW	0	--	--	7.81×10^3	2.12×10^3	7.61×10^3	1.75×10^4
W	0	--	2.35×10^3	9.71×10^3	3.05×10^3	1.31×10^4	2.83×10^4
WNW	0	4.05×10^3	3.63×10^3	1.90×10^5	1.16×10^5	2.58×10^4	3.39×10^5
NW	0	1.13×10^3	1.38×10^4	5.01×10^4	7.77×10^3	1.58×10^3	7.44×10^4
NNW	0	3.97×10^3	3.86×10^4	1.25×10^4	1.33×10^4	4.56×10^3	7.29×10^4
Total	0	1.15×10^4	8.54×10^4	3.20×10^5	2.10×10^5	2.26×10^5	8.52×10^5
MILK PRODUCTION (l/yr)							
N	0	1.64×10^4	1.03×10^5	1.72×10^5	1.41×10^6	5.57×10^6	7.28×10^6
NNE	0	1.31×10^4	1.03×10^5	1.72×10^5	3.68×10^5	6.06×10^5	1.26×10^6
NE	0	5.73×10^3	1.22×10^5	1.33×10^6	2.15×10^6	1.39×10^6	4.99×10^6
ENE	0	1.58×10^3	1.80×10^5	1.92×10^6	4.82×10^6	5.46×10^6	1.24×10^7
E	0	1.85×10^3	1.80×10^5	1.74×10^6	4.15×10^6	5.76×10^6	1.18×10^7
ESE	0	4.51×10	1.80×10^5	9.31×10^5	2.84×10^6	1.46×10^6	5.41×10^6
SE	0	--	1.21×10^5	4.52×10^4	1.80×10^5	4.00×10^5	7.46×10^5
SSE	0	--	9.38×10^4	2.41×10^5	3.52×10^5	5.64×10^5	1.25×10^6

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Table B-4. Population and annual food production within 80 kilometers of the SRP site center^a (continued)

Direction	Distance (km)						
	0-8	8-16	16-32	32-48	48-64	64-80	0-80
MILK PRODUCTION (l/yr) (continued)							
S	0	--	3.31×10^5	5.74×10^5	7.70×10^5	9.97×10^5	2.67×10^6
SSW	0	--	3.58×10^5	1.89×10^6	6.40×10^6	7.61×10^6	1.63×10^7
SW	0	7.65×10^3	3.87×10^5	6.71×10^5	3.07×10^6	2.84×10^6	6.97×10^6
WSW	0	2.47×10^3	3.53×10^5	6.68×10^5	1.05×10^6	2.40×10^6	4.47×10^6
W	0	1.16×10^4	1.81×10^5	3.79×10^5	1.01×10^6	1.77×10^6	3.36×10^6
WNW	0	1.38×10^4	1.79×10^5	3.46×10^5	6.13×10^5	8.55×10^5	2.01×10^6
NW	0	1.75×10^4	1.03×10^5	4.24×10^5	1.16×10^6	7.81×10^5	2.49×10^6
NNW	0	1.79×10^4	1.03×10^5	2.95×10^5	1.48×10^6	3.14×10^6	5.04×10^6
Total	0	1.10×10^5	3.08×10^6	1.18×10^7	3.18×10^7	4.16×10^7	8.84×10^7
MEAT PRODUCTION (kg/yr)							
N	0	8.32×10^4	5.24×10^5	8.73×10^5	1.41×10^6	3.15×10^6	6.05×10^6
NNE	0	6.63×10^4	5.24×10^5	8.73×10^5	2.29×10^6	4.06×10^6	7.81×10^6
NE	0	2.37×10^4	4.71×10^5	7.80×10^5	1.71×10^6	3.01×10^6	5.99×10^6
ENE	0	2.65×10^4	3.02×10^5	5.50×10^5	8.87×10^5	1.06×10^6	2.80×10^6
E	0	3.10×10^3	3.02×10^5	4.74×10^5	6.89×10^5	1.03×10^6	2.50×10^6
ESE	0	7.56×10^1	3.02×10^5	4.66×10^5	6.14×10^5	7.10×10^5	2.09×10^6
SE	0	--	2.74×10^5	3.82×10^5	6.56×10^5	1.00×10^6	2.31×10^6
SSE	0	--	2.35×10^5	4.35×10^5	6.19×10^5	9.88×10^5	2.28×10^6
S	0	--	1.75×10^5	4.58×10^5	7.32×10^5	1.02×10^6	2.39×10^6
SSW	0	--	1.57×10^5	3.93×10^5	1.13×10^6	1.58×10^6	3.26×10^6
SW	0	2.29×10^3	1.33×10^5	2.01×10^5	5.76×10^5	7.57×10^5	1.67×10^6
WSW	0	1.06×10^4	1.75×10^5	2.00×10^5	3.09×10^5	6.65×10^5	1.36×10^6
W	0	5.90×10^4	1.66×10^5	1.19×10^5	2.91×10^5	5.11×10^5	1.15×10^6
WNW	0	7.01×10^4	1.75×10^5	1.09×10^5	1.76×10^5	2.45×10^5	7.75×10^5

Table B-4. Population and annual food production within 80 kilometers of the SRP site center^a (continued)

Direction	Distance (km)						
	0-8	8-16	16-32	32-48	48-64	64-80	0-80
MEAT PRODUCTION (kg/yr) (continued)							
NW	0	8.86×10^4	5.24×10^5	6.98×10^5	5.83×10^5	7.01×10^5	2.60×10^6
NNW	0	9.11×10^4	5.24×10^5	8.20×10^5	7.14×10^5	1.45×10^5	3.60×10^6
Total	0	5.01×10^5	4.96×10^6	7.83×10^6	1.34×10^7	2.20×10^7	4.86×10^7
VEGETABLE PRODUCTION (kg/yr)							
N	0	7.39×10^4	4.65×10^5	7.75×10^5	2.16×10^6	3.11×10^6	6.58×10^6
NNE	0	5.89×10^4	4.65×10^5	7.75×10^5	1.18×10^6	1.61×10^6	4.09×10^6
NE	0	4.13×10^4	9.71×10^5	1.08×10^6	1.59×10^6	1.93×10^6	5.61×10^6
ENE	0	2.25×10^4	2.57×10^6	2.89×10^6	2.21×10^6	2.78×10^6	1.05×10^7
E	0	2.64×10^4	2.57×10^6	3.01×10^6	2.72×10^6	3.03×10^6	1.14×10^7
ESE	0	6.44×10^2	2.57×10^6	3.82×10^6	3.44×10^6	9.66×10^5	1.08×10^7
SE	0	--	2.73×10^6	4.97×10^6	4.70×10^6	2.89×10^6	1.53×10^7
SSE	0	--	2.65×10^6	3.71×10^6	5.01×10^6	3.16×10^6	1.45×10^7
S	0	--	1.36×10^6	1.69×10^6	2.50×10^6	3.27×10^6	8.82×10^6
SSW	0	--	1.15×10^6	1.33×10^6	1.86×10^6	2.55×10^6	6.89×10^6
SW	0	1.51×10^4	9.20×10^5	1.33×10^6	1.81×10^6	1.97×10^6	6.04×10^6
WSW	0	1.01×10^4	7.21×10^5	1.31×10^6	1.86×10^6	2.41×10^6	6.31×10^6
W	0	5.23×10^4	1.86×10^5	3.17×10^5	1.18×10^6	2.77×10^6	4.51×10^6
WNW	0	6.22×10^4	1.94×10^5	1.70×10^5	4.89×10^4	1.36×10^6	1.83×10^6
NW	0	7.86×10^4	4.65×10^5	1.59×10^6	4.20×10^6	2.27×10^6	8.59×10^6
NNW	0	8.08×10^4	4.65×10^5	1.25×10^6	5.70×10^6	6.38×10^6	1.39×10^7
Total	0	5.23×10^5	2.05×10^7	3.00×10^7	4.22×10^7	4.24×10^7	1.36×10^8

^aAdapted from Du Pont (1982).

Table B-5. Parameters and demographic data used in calculating doses to the 80-kilometer population

Average individual parameters ^a	Child	Teen	Adult
Inhalation (m ³ /yr)	3,700	8,000	8,000
Ingestion ^b			
Cow's milk (ℓ/yr)	170	200	110
Meat (kg/yr)	37	59	95
Leafy vegetables (kg/yr) ^c	10	20	30
Fruits, vegetables, and grains (kg/yr) ^d	200	240	190
External exposure			
Transmission factor for shielding by residential structures	0.5	0.5	0.5
Demographic data, CY 2000 ^d			
80-kilometer residential population (852,000) age-group distribution	20.8	11.8	67.4

^aData are recommended values from Regulatory Guide 1.109 (NRC, 1977).

^bFoodstuff obtained at large from the 80-kilometer agricultural production of man's foods; any insufficiency is assumed to be imported (uncontaminated). Crop yield and animal feeding data for the 80-kilometer vicinity are presented in Du Pont (1981).

^cData from Eckerman et al. (1980).

^d1970-census data projected to the assumed midpoint of operations.

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location of the maximum total-body dose rate (millirem per year of operation) to the age-specific individuals along the SRP buffer-zone boundary (the nearest possible approach of the residential population). Boundary locations are selected for each of the four support facilities (i.e., the 200-F and 200-H separations areas, the 300-M fuel fabrication area, and the 400-D heavy-water rework area) in each cardinal direction. For each location the doses from releases from L-Reactor and its support facilities are added to arrive at the total dose for that location. This method is used to determine the location at which a member of the public would receive the highest individual dose.

The maximally exposed individual is assumed to reside continuously at the location of highest potential exposure. All individual doses are 50-year dose commitments. Parameters used in calculating doses to maximally exposed individuals are summarized in Table B-6.

The response to radiation will vary with the age of the individual, or group of individuals, receiving the dose. Also, the stage of an individual's physical development and the chemical form of any radioactive material ingested will contribute to differences in its rate of uptake and internal deposition. For this reason, age-specific dose commitment factors were used to calculate dose. The age groups considered were infant (0 to 1 year old), child (1 to 11 years old), teen (11 to 17 years old), and adult (17 years and older). The dose factors used for exposure to noble gases are the factors in Table B-1 of Regulatory Guide 1.109 (NRC, 1977), plus lung exposure factors contained in the GASPAR code. The remainder of the dose factor library is that described in Appendix C of NUREG/CR-1276 (Simpson and McGill, 1980); for the inhalation and ingestion pathways, this incorporates the age-specific 50-year dose commitment factors of Hoenes and Soldat (1977) with NRC-approved corrections in actinide factors.

The following pathways and their descriptions were considered for the atmospheric dose assessment:

1. Plume--External dose from radioactive materials transported by the atmosphere.
2. Ground--External dose from radioactive material deposited on the ground.
3. Inhalation--Internal dose from inhalation of radioactive materials transported by the atmosphere.
4. Vegetation--Internal dose from consumption of vegetable food crops that are contaminated by radioactive material deposited from the atmosphere.
5. Milk--Internal dose from consumption of milk that is contaminated by radioactive material deposited from the atmosphere on vegetation.
6. Meat--Internal dose from consumption of meat products that are contaminated by radioactive material deposited from the atmosphere on vegetation.

The results of dose calculations to the maximally exposed individual and to the population within 80 kilometers of Savannah River Plant from atmospheric releases are contained in Tables B-7 through B-17. For releases from L-Reactor

Table B-6. Parameters used in calculating dose to maximally exposed individuals^a

Parameter	Infant	Child	Teen	Adult
Inhalation (m ³ /yr)	1,400	3,700	8,000	8,000
Ingestion ^b				
Cow's milk (l/yr)	330	330	400	310
Meat (kg/yr)	0	41	65	110
Leafy vegetables (kg/yr) ^c	0	26	42	64
Fruits, vegetables, and grains (kg/yr) ^d	0	520	630	520
External exposure				
Transmission factor for shielding from buildings	0.7	0.7	0.7	0.7

^aData are recommended values from Regulatory Guide 1.109 (NRC, 1977).

^bFoodstuff produced at the reference family's location, except as noted, where exposure to the air-released radionuclides is at a maximum. Crop yield and animal feeding parameters are presented in Du Pont (1981).

^cSeventy-five percent taken from reference family's garden (March-November growing season); remainder imported (uncontaminated).

^dSeventy-six percent taken from reference family's crops (Regulatory Guide 1.109 recommended value) (NRC, 1977); remainder imported (uncontaminated).

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Table B-7. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor with seepage basin in first year (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	3.97×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	5.65×10^{-3}	5.66×10^{-3}	6.65×10^{-3}	5.63×10^{-3}	5.63×10^{-3}	6.97×10^{-3}	5.63×10^{-3}	5.63×10^{-3}
Meat ingestion	1.10×10^{-3}	1.10×10^{-3}	2.14×10^{-3}	1.10×10^{-3}	1.10×10^{-3}	1.17×10^{-3}	1.10×10^{-3}	1.10×10^{-3}
Milk ingestion	2.05×10^{-3}	2.05×10^{-3}	2.36×10^{-3}	2.05×10^{-3}	2.05×10^{-3}	2.78×10^{-3}	2.05×10^{-3}	2.05×10^{-3}
Inhalation	3.79×10^{-3}	3.79×10^{-3}	1.42×10^{-5}	3.80×10^{-3}	3.80×10^{-3}	3.82×10^{-3}	3.80×10^{-3}	3.79×10^{-3}
Total	5.22×10^{-2}	5.22×10^{-2}	5.08×10^{-2}	5.22×10^{-2}	5.22×10^{-2}	5.44×10^{-2}	5.22×10^{-2}	7.77×10^{-2}
TEENAGER								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	7.11×10^{-3}	7.11×10^{-3}	1.06×10^{-2}	7.08×10^{-3}	7.09×10^{-3}	8.20×10^{-3}	7.08×10^{-3}	7.08×10^{-3}
Meat ingestion	7.62×10^{-4}	7.62×10^{-4}	1.81×10^{-3}	7.62×10^{-4}	7.62×10^{-4}	8.12×10^{-4}	7.62×10^{-4}	7.62×10^{-4}
Milk ingestion	2.92×10^{-3}	2.92×10^{-3}	4.34×10^{-3}	2.92×10^{-3}	2.92×10^{-3}	4.08×10^{-3}	2.92×10^{-3}	2.92×10^{-3}
Inhalation	3.82×10^{-3}	3.82×10^{-3}	1.51×10^{-5}	3.82×10^{-3}	3.82×10^{-3}	3.85×10^{-3}	3.82×10^{-3}	3.82×10^{-3}
Total	5.42×10^{-2}	5.42×10^{-2}	5.64×10^{-2}	5.42×10^{-2}	5.42×10^{-2}	5.66×10^{-2}	5.42×10^{-2}	7.97×10^{-2}
CHILD								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	1.27×10^{-2}	1.26×10^{-2}	2.52×10^{-2}	1.26×10^{-2}	1.26×10^{-2}	1.43×10^{-2}	1.26×10^{-2}	1.26×10^{-2}
Meat ingestion	1.16×10^{-3}	1.16×10^{-3}	3.40×10^{-3}	1.16×10^{-3}	1.16×10^{-3}	1.24×10^{-3}	1.16×10^{-3}	1.16×10^{-3}
Milk ingestion	5.37×10^{-3}	5.37×10^{-3}	1.07×10^{-2}	5.37×10^{-3}	5.38×10^{-3}	7.66×10^{-3}	5.37×10^{-3}	5.37×10^{-3}
Inhalation	3.38×10^{-3}	3.38×10^{-3}	1.27×10^{-5}	3.38×10^{-3}	3.38×10^{-3}	3.41×10^{-3}	3.38×10^{-3}	3.38×10^{-3}
Total	6.22×10^{-2}	6.22×10^{-2}	7.88×10^{-2}	6.21×10^{-2}	6.21×10^{-2}	6.62×10^{-2}	6.22×10^{-2}	8.76×10^{-2}

Table B-7. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor with seepage basin in first year (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	9.36×10^{-3}	9.35×10^{-3}	2.08×10^{-2}	9.37×10^{-3}	9.37×10^{-3}	1.49×10^{-2}	9.35×10^{-3}	9.35×10^{-3}
Inhalation	1.94×10^{-3}	1.94×10^{-3}	5.09×10^{-6}	1.94×10^{-3}	1.94×10^{-3}	1.97×10^{-3}	1.94×10^{-3}	1.94×10^{-3}
Total	5.09×10^{-2}	5.09×10^{-2}	6.04×10^{-2}	5.09×10^{-2}	5.09×10^{-2}	5.65×10^{-2}	5.10×10^{-2}	7.64×10^{-2}

Table B-8. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor without seepage basin in first year (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	3.97×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	5.33×10^{-3}	5.33×10^{-3}	6.65×10^{-3}	5.31×10^{-3}	5.31×10^{-3}	6.64×10^{-3}	5.30×10^{-3}	5.30×10^{-3}
Meat ingestion	1.05×10^{-3}	1.05×10^{-3}	2.14×10^{-3}	1.05×10^{-3}	1.05×10^{-3}	1.12×10^{-3}	1.05×10^{-3}	1.05×10^{-3}
Milk ingestion	1.93×10^{-3}	1.93×10^{-3}	2.36×10^{-3}	1.93×10^{-3}	1.94×10^{-3}	2.67×10^{-3}	1.93×10^{-3}	1.93×10^{-3}
Inhalation	3.52×10^{-3}	3.52×10^{-3}	1.42×10^{-5}	3.52×10^{-3}	3.52×10^{-3}	3.54×10^{-3}	3.52×10^{-3}	3.52×10^{-3}
Total	5.15×10^{-2}	5.15×10^{-2}	5.08×10^{-2}	5.14×10^{-2}	5.14×10^{-2}	5.36×10^{-2}	5.15×10^{-2}	7.69×10^{-2}
TEENAGER								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	6.73×10^{-3}	6.73×10^{-3}	1.06×10^{-2}	6.70×10^{-3}	6.71×10^{-3}	7.82×10^{-3}	6.70×10^{-3}	6.70×10^{-3}
Meat ingestion	7.33×10^{-4}	7.33×10^{-4}	1.81×10^{-3}	7.33×10^{-4}	7.34×10^{-4}	7.83×10^{-4}	7.33×10^{-4}	7.33×10^{-4}
Milk ingestion	2.77×10^{-3}	2.77×10^{-3}	4.34×10^{-3}	2.77×10^{-3}	2.78×10^{-3}	3.93×10^{-3}	2.77×10^{-3}	2.77×10^{-3}
Inhalation	3.54×10^{-3}	3.54×10^{-3}	1.51×10^{-5}	3.54×10^{-3}	3.54×10^{-3}	3.57×10^{-3}	3.55×10^{-3}	3.54×10^{-3}
Total	5.34×10^{-2}	5.34×10^{-2}	5.64×10^{-2}	5.34×10^{-2}	5.34×10^{-2}	5.57×10^{-2}	5.34×10^{-2}	7.89×10^{-2}
CHILD								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	1.21×10^{-2}	1.20×10^{-2}	2.52×10^{-2}	1.20×10^{-2}	1.20×10^{-2}	1.37×10^{-2}	1.20×10^{-2}	1.20×10^{-2}
Meat ingestion	1.13×10^{-3}	1.13×10^{-3}	3.40×10^{-3}	1.13×10^{-3}	1.13×10^{-3}	1.20×10^{-3}	1.13×10^{-3}	1.13×10^{-3}
Milk ingestion	5.14×10^{-3}	5.13×10^{-3}	1.07×10^{-2}	5.14×10^{-3}	5.14×10^{-3}	7.43×10^{-3}	5.13×10^{-3}	5.13×10^{-3}
Inhalation	3.13×10^{-3}	3.13×10^{-3}	1.27×10^{-5}	3.13×10^{-3}	3.13×10^{-3}	3.16×10^{-3}	3.14×10^{-3}	3.13×10^{-3}
Total	6.11×10^{-2}	6.10×10^{-2}	7.88×10^{-2}	6.10×10^{-2}	6.10×10^{-2}	6.51×10^{-2}	6.11×10^{-2}	8.65×10^{-2}

Table B-8. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor without seepage basin in first year (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.96×10^{-2}	3.97×10^{-2}	6.51×10^{-2}
Ground plane	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	2.54×10^{-7}	3.09×10^{-7}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	9.01×10^{-3}	9.00×10^{-3}	2.08×10^{-2}	9.01×10^{-3}	9.02×10^{-3}	1.46×10^{-2}	9.00×10^{-3}	9.00×10^{-3}
Inhalation	1.80×10^{-3}	1.80×10^{-3}	5.09×10^{-6}	1.80×10^{-3}	1.80×10^{-3}	1.83×10^{-5}	1.80×10^{-3}	1.80×10^{-3}
Total	5.04×10^{-2}	5.04×10^{-2}	6.04×10^{-2}	5.04×10^{-2}	5.04×10^{-2}	5.60×10^{-2}	5.05×10^{-2}	7.59×10^{-2}

Table B-9. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor with seepage basin in tenth year (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	6.70×10^{-2}	6.70×10^{-2}	9.79×10^{-3}	6.69×10^{-2}	6.69×10^{-2}	6.90×10^{-2}	6.69×10^{-2}	6.69×10^{-2}
Meat ingestion	1.03×10^{-2}	1.03×10^{-2}	3.12×10^{-3}	1.03×10^{-2}	1.03×10^{-2}	1.05×10^{-2}	1.03×10^{-2}	1.03×10^{-2}
Milk ingestion	2.35×10^{-2}	2.35×10^{-2}	3.43×10^{-3}	2.35×10^{-2}	2.35×10^{-2}	2.46×10^{-2}	2.35×10^{-2}	2.35×10^{-2}
Inhalation	5.49×10^{-2}	5.49×10^{-2}	2.05×10^{-5}	5.49×10^{-2}	5.49×10^{-2}	5.49×10^{-2}	5.49×10^{-2}	5.49×10^{-2}
Total	2.14×10^{-1}	2.14×10^{-1}	7.45×10^{-2}	2.14×10^{-1}	2.14×10^{-1}	2.17×10^{-1}	2.14×10^{-1}	2.51×10^{-1}
TEENAGER								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	7.86×10^{-2}	7.86×10^{-2}	1.56×10^{-2}	7.86×10^{-2}	7.86×10^{-2}	8.03×10^{-2}	7.86×10^{-2}	7.86×10^{-2}
Meat ingestion	6.33×10^{-3}	6.33×10^{-3}	2.63×10^{-3}	6.33×10^{-3}	6.33×10^{-3}	6.40×10^{-3}	6.33×10^{-3}	6.33×10^{-3}
Milk ingestion	3.10×10^{-2}	3.10×10^{-2}	6.31×10^{-3}	3.10×10^{-2}	3.10×10^{-2}	3.28×10^{-2}	3.10×10^{-2}	3.10×10^{-2}
Inhalation	5.52×10^{-2}	5.52×10^{-2}	2.19×10^{-5}	5.52×10^{-2}	5.52×10^{-2}	5.52×10^{-2}	5.52×10^{-2}	5.52×10^{-2}
Total	2.29×10^{-1}	2.29×10^{-1}	8.27×10^{-2}	2.29×10^{-1}	2.29×10^{-1}	2.33×10^{-1}	2.29×10^{-1}	2.67×10^{-1}
CHILD								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	1.25×10^{-1}	1.25×10^{-1}	3.69×10^{-2}	1.25×10^{-1}	1.25×10^{-1}	1.27×10^{-1}	1.25×10^{-1}	1.25×10^{-1}
Meat ingestion	7.99×10^{-3}	7.99×10^{-3}	4.94×10^{-3}	7.99×10^{-3}	7.99×10^{-3}	8.11×10^{-3}	7.99×10^{-3}	7.99×10^{-3}
Milk ingestion	5.01×10^{-2}	5.01×10^{-2}	1.55×10^{-2}	5.01×10^{-2}	5.01×10^{-2}	5.35×10^{-2}	5.01×10^{-2}	5.01×10^{-2}
Inhalation	4.88×10^{-2}	4.88×10^{-2}	1.83×10^{-5}	4.88×10^{-2}	4.88×10^{-2}	4.89×10^{-2}	4.88×10^{-2}	4.88×10^{-2}
Total	2.90×10^{-1}	2.90×10^{-1}	1.15×10^{-1}	2.90×10^{-1}	2.90×10^{-1}	2.96×10^{-1}	2.90×10^{-1}	3.27×10^{-1}

Table B-9. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor with seepage basin in tenth year (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	7.78×10^{-2}	7.77×10^{-2}	3.02×10^{-2}	7.78×10^{-2}	7.78×10^{-2}	8.62×10^{-2}	7.77×10^{-2}	7.77×10^{-2}
Inhalation	2.81×10^{-2}	2.81×10^{-2}	7.38×10^{-6}	2.81×10^{-2}	2.81×10^{-2}	2.81×10^{-2}	2.81×10^{-2}	2.81×10^{-2}
Total	1.64×10^{-1}	1.64×10^{-1}	8.84×10^{-2}	1.64×10^{-1}	1.64×10^{-1}	1.72×10^{-1}	1.64×10^{-1}	2.01×10^{-1}

Table B-10. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor without seepage basin in tenth year (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	6.24×10^{-2}	6.24×10^{-2}	9.79×10^{-3}	6.24×10^{-2}	6.24×10^{-2}	6.44×10^{-2}	6.24×10^{-2}	6.24×10^{-2}
Meat ingestion	9.67×10^{-3}	9.67×10^{-3}	3.12×10^{-3}	9.67×10^{-3}	9.67×10^{-3}	9.77×10^{-3}	9.67×10^{-3}	9.67×10^{-3}
Milk ingestion	2.19×10^{-2}	2.19×10^{-2}	3.43×10^{-3}	2.19×10^{-2}	2.19×10^{-2}	2.30×10^{-2}	2.19×10^{-2}	2.19×10^{-2}
Inhalation	5.10×10^{-2}	5.10×10^{-2}	2.05×10^{-5}	5.10×10^{-2}	5.10×10^{-2}	5.11×10^{-2}	5.10×10^{-2}	5.10×10^{-2}
Total	2.03×10^{-1}	2.03×10^{-1}	7.45×10^{-2}	2.03×10^{-1}	2.03×10^{-1}	2.06×10^{-1}	2.03×10^{-1}	2.41×10^{-1}
TEENAGER								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	7.33×10^{-2}	7.33×10^{-2}	1.56×10^{-2}	7.33×10^{-2}	7.33×10^{-2}	7.50×10^{-2}	7.33×10^{-2}	7.33×10^{-2}
Meat ingestion	5.92×10^{-3}	5.92×10^{-3}	2.63×10^{-3}	5.92×10^{-3}	5.92×10^{-3}	6.00×10^{-3}	5.92×10^{-3}	5.92×10^{-3}
Milk ingestion	2.89×10^{-2}	2.89×10^{-2}	6.31×10^{-3}	2.89×10^{-2}	2.89×10^{-2}	3.07×10^{-2}	2.89×10^{-2}	2.89×10^{-2}
Inhalation	5.13×10^{-2}	5.13×10^{-2}	2.19×10^{-5}	5.13×10^{-2}	5.13×10^{-2}	5.14×10^{-2}	5.13×10^{-2}	5.13×10^{-2}
Total	2.18×10^{-1}	2.18×10^{-1}	8.27×10^{-2}	2.18×10^{-1}	2.18×10^{-1}	2.21×10^{-1}	2.18×10^{-1}	2.55×10^{-1}
CHILD								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	1.16×10^{-1}	1.16×10^{-1}	3.69×10^{-2}	1.16×10^{-1}	1.16×10^{-1}	1.19×10^{-1}	1.16×10^{-1}	1.16×10^{-1}
Meat ingestion	7.50×10^{-3}	7.50×10^{-3}	4.94×10^{-3}	7.50×10^{-3}	7.50×10^{-3}	7.62×10^{-3}	7.50×10^{-3}	7.50×10^{-3}
Milk ingestion	4.68×10^{-2}	4.68×10^{-2}	1.55×10^{-2}	4.68×10^{-2}	4.68×10^{-2}	5.03×10^{-2}	4.68×10^{-2}	4.68×10^{-2}
Inhalation	4.54×10^{-2}	4.54×10^{-2}	1.83×10^{-5}	4.54×10^{-2}	4.54×10^{-2}	4.54×10^{-2}	4.54×10^{-2}	4.54×10^{-2}
Total	2.74×10^{-1}	2.74×10^{-1}	1.15×10^{-1}	2.74×10^{-1}	2.74×10^{-1}	2.80×10^{-1}	2.74×10^{-1}	3.12×10^{-1}

Table B-10. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor without seepage basin in tenth year (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	5.82×10^{-2}	9.56×10^{-2}
Ground plane	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	3.84×10^{-7}	4.66×10^{-7}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	7.28×10^{-2}	7.28×10^{-2}	3.02×10^{-2}	7.28×10^{-2}	7.28×10^{-2}	8.12×10^{-2}	7.28×10^{-2}	7.28×10^{-2}
Inhalation	2.61×10^{-2}	2.61×10^{-2}	7.38×10^{-6}	2.61×10^{-2}	2.61×10^{-2}	2.61×10^{-2}	2.61×10^{-2}	2.61×10^{-2}
Total	1.57×10^{-1}	1.57×10^{-1}	8.84×10^{-2}	1.57×10^{-1}	1.57×10^{-1}	1.65×10^{-1}	1.57×10^{-1}	1.94×10^{-1}

Table B-11. Eighty-kilometer population dose resulting from atmospheric releases from operation of L-Reactor with seepage basin in first year (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.60	1.60	1.60	1.60	1.60	1.60	1.60	2.99
Ground plane	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.45×10^{-5}
Vegetation ingestion	5.20×10^{-1}	5.20×10^{-1}	7.83×10^{-1}	5.19×10^{-1}	5.19×10^{-1}	7.68×10^{-1}	5.18×10^{-1}	5.18×10^{-1}
Meat ingestion	1.20×10^{-1}	1.20×10^{-1}	2.66×10^{-1}	1.20×10^{-1}	1.20×10^{-1}	1.24×10^{-1}	1.20×10^{-1}	1.20×10^{-1}
Milk ingestion	1.41×10^{-1}	1.41×10^{-1}	2.26×10^{-1}	1.41×10^{-1}	1.41×10^{-1}	1.66×10^{-1}	1.41×10^{-1}	1.41×10^{-1}
Inhalation	6.26×10^{-1}	6.26×10^{-1}	2.24×10^{-3}	6.26×10^{-1}	6.26×10^{-1}	6.30×10^{-1}	6.26×10^{-1}	6.26×10^{-1}
Total	3.00	3.00	2.88	3.00	3.00	3.28	3.00	4.40

Table B-12. Eighty-kilometer population dose resulting from atmospheric releases from operation of L-Reactor with seepage basin in tenth year (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.60	1.60	1.60	1.60	1.60	1.60	1.60	2.99
Ground plane	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.45×10^{-5}
Vegetation ingestion	3.94	3.94	7.83×10^{-1}	3.94	3.94	4.19	3.94	3.94
Meat ingestion	7.18×10^{-1}	7.18×10^{-1}	2.66×10^{-1}	7.18×10^{-1}	7.18×10^{-1}	7.23×10^{-1}	7.18×10^{-1}	7.18×10^{-1}
Milk ingestion	1.01	1.01	2.26×10^{-1}	1.01	1.01	1.04	1.01	1.01
Inhalation	6.26	6.26	2.24×10^{-3}	6.26	6.26	6.26	6.26	6.26
Total	1.35×10^1	1.35×10^1	2.88	1.35×10^1	1.35×10^1	1.38×10^1	1.35×10^1	1.49×10^1

Table B-13. Eighty-kilometer population dose resulting from atmospheric releases from operation of L-Reactor without seepage basin in first year (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.60	1.60	1.60	1.60	1.60	1.60	1.60	2.99
Ground plane	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.45×10^{-5}
Vegetation ingestion	4.95×10^{-1}	4.95×10^{-1}	7.83×10^{-1}	4.94×10^{-1}	4.94×10^{-1}	7.41×10^{-1}	4.93×10^{-1}	4.93×10^{-1}
Meat ingestion	1.15×10^{-1}	1.15×10^{-1}	2.66×10^{-1}	1.15×10^{-1}	1.15×10^{-1}	1.20×10^{-1}	1.15×10^{-1}	1.15×10^{-1}
Milk ingestion	1.35×10^{-1}	1.35×10^{-1}	2.26×10^{-1}	1.35×10^{-1}	1.35×10^{-1}	1.60×10^{-1}	1.35×10^{-1}	1.35×10^{-1}
Inhalation	5.85×10^{-1}	5.85×10^{-1}	2.24×10^{-3}	5.85×10^{-1}	5.85×10^{-1}	5.88×10^{-1}	5.85×10^{-1}	5.85×10^{-1}
Total	2.93	2.93	2.88	2.93	2.93	3.20	2.93	4.32

Table B-14. Eighty-kilometer population dose resulting from atmospheric releases from operation of L-Reactor without seepage basin in tenth year (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.60	1.60	1.60	1.60	1.60	1.60	1.60	2.99
Ground plane	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.01×10^{-5}	2.45×10^{-5}
Vegetation ingestion	3.69	3.69	7.83×10^{-1}	3.69	3.69	3.94	3.69	3.69
Meat ingestion	6.74×10^{-1}	6.74×10^{-1}	2.66×10^{-1}	6.74×10^{-1}	6.74×10^{-1}	6.78×10^{-1}	6.74×10^{-1}	6.74×10^{-1}
Milk ingestion	9.49×10^{-1}	9.49×10^{-1}	2.26×10^{-1}	9.49×10^{-1}	9.49×10^{-1}	9.73×10^{-1}	9.49×10^{-1}	9.49×10^{-1}
Inhalation	5.85	5.85	2.24×10^{-3}	5.85	5.85	5.85	5.85	5.85
Total	1.28×10^1	1.28×10^1	2.88	1.28×10^1	1.28×10^1	1.30×10^1	1.28×10^1	1.41×10^1

Table B-15. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor support facilities in first year^a (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	2.66×10^{-3}	1.20×10^{-1}
Ground plane	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.84×10^{-4}
Vegetation ingestion	2.13×10^{-2}	2.27×10^{-2}	9.54×10^{-3}	2.10×10^{-2}	2.12×10^{-2}	4.44×10^{-1}	2.06×10^{-2}	2.06×10^{-2}
Meat ingestion	3.24×10^{-3}	1.03×10^{-2}	1.33×10^{-3}	3.22×10^{-3}	3.43×10^{-3}	1.73×10^{-2}	3.21×10^{-3}	3.21×10^{-3}
Milk ingestion	7.34×10^{-3}	7.26×10^{-3}	1.45×10^{-3}	7.29×10^{-3}	7.31×10^{-3}	7.81×10^{-2}	7.24×10^{-3}	7.24×10^{-3}
Inhalation	1.74×10^{-2}	1.68×10^{-2}	2.02×10^{-2}	2.08×10^{-2}	1.97×10^{-2}	1.82×10^{-2}	1.86×10^{-2}	1.68×10^{-2}
Total	5.04×10^{-2}	5.82×10^{-2}	3.37×10^{-2}	5.34×10^{-2}	5.28×10^{-2}	5.58×10^{-1}	5.24×10^{-2}	1.68×10^{-1}
TEENAGER								
Plume immersion	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	2.66×10^{-3}	1.20×10^{-1}
Ground plane	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.84×10^{-4}
Vegetation ingestion	2.49×10^{-2}	2.68×10^{-2}	1.39×10^{-2}	2.48×10^{-2}	2.51×10^{-2}	3.46×10^{-1}	2.42×10^{-2}	2.42×10^{-2}
Meat ingestion	1.99×10^{-3}	6.37×10^{-3}	1.12×10^{-3}	1.98×10^{-3}	2.16×10^{-3}	7.48×10^{-3}	1.97×10^{-3}	1.97×10^{-3}
Milk ingestion	9.67×10^{-3}	9.59×10^{-3}	2.64×10^{-3}	9.65×10^{-3}	9.68×10^{-3}	7.03×10^{-2}	9.57×10^{-3}	9.57×10^{-3}
Inhalation	1.75×10^{-2}	1.69×10^{-2}	2.13×10^{-2}	2.12×10^{-2}	2.00×10^{-2}	1.78×10^{-2}	2.00×10^{-2}	1.69×10^{-2}
Total	5.52×10^{-2}	6.08×10^{-2}	4.01×10^{-2}	5.87×10^{-2}	5.81×10^{-2}	4.42×10^{-1}	5.86×10^{-2}	1.73×10^{-1}
CHILD								
Plume immersion	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	2.66×10^{-3}	1.20×10^{-1}
Ground plane	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.84×10^{-4}
Vegetation ingestion	3.94×10^{-2}	4.06×10^{-2}	3.03×10^{-2}	3.95×10^{-2}	4.00×10^{-2}	3.45×10^{-1}	3.86×10^{-2}	3.86×10^{-2}
Meat ingestion	2.55×10^{-3}	5.20×10^{-3}	2.10×10^{-3}	2.53×10^{-3}	2.76×10^{-3}	6.61×10^{-3}	2.52×10^{-3}	2.52×10^{-3}
Milk ingestion	1.56×10^{-2}	1.56×10^{-2}	6.43×10^{-3}	1.57×10^{-2}	1.57×10^{-2}	7.51×10^{-2}	1.55×10^{-2}	1.55×10^{-2}
Inhalation	1.54×10^{-2}	1.49×10^{-2}	1.68×10^{-2}	1.81×10^{-2}	1.70×10^{-2}	1.55×10^{-2}	1.78×10^{-2}	1.49×10^{-2}
Total	7.42×10^{-2}	7.74×10^{-2}	5.68×10^{-2}	7.69×10^{-2}	7.66×10^{-2}	4.43×10^{-1}	7.72×10^{-2}	1.92×10^{-1}

Table B-15. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor support facilities in first year^a (In millirems per year) (continued)

TC

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	9.99×10^{-4}	2.66×10^{-3}	1.20×10^{-1}
Ground plane	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.28×10^{-4}	1.84×10^{-4}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	2.44×10^{-2}	2.43×10^{-2}	1.23×10^{-2}	2.46×10^{-2}	2.46×10^{-2}	1.69×10^{-1}	2.43×10^{-2}	2.42×10^{-2}
Inhalation	8.79×10^{-3}	8.58×10^{-3}	6.72×10^{-3}	9.84×10^{-3}	9.42×10^{-3}	9.12×10^{-3}	1.04×10^{-2}	8.58×10^{-3}
Total	3.43×10^{-2}	3.40×10^{-2}	2.01×10^{-2}	3.55×10^{-2}	3.51×10^{-2}	1.80×10^{-1}	3.74×10^{-2}	1.53×10^{-1}

^aIn the support facilities, only the doses resulting from L-Reactor operation are included.

TC

Table B-16. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor support facilities in tenth year^a (in millirems per year)

TC

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	1.89×10^{-3}	8.54×10^{-2}
Ground plane	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	2.19×10^{-4}
Vegetation ingestion	6.21×10^{-3}	7.90×10^{-3}	9.86×10^{-3}	5.83×10^{-3}	6.11×10^{-3}	5.07×10^{-1}	5.35×10^{-3}	5.34×10^{-3}
Meat ingestion	9.39×10^{-4}	9.28×10^{-3}	1.02×10^{-3}	9.08×10^{-4}	1.16×10^{-3}	1.76×10^{-2}	8.99×10^{-4}	8.99×10^{-4}
Milk ingestion	2.02×10^{-3}	1.92×10^{-3}	1.11×10^{-3}	1.95×10^{-3}	1.98×10^{-3}	8.60×10^{-2}	1.90×10^{-3}	1.90×10^{-3}
Inhalation	4.54×10^{-3}	4.13×10^{-3}	1.36×10^{-2}	6.82×10^{-3}	6.11×10^{-3}	5.09×10^{-3}	5.36×10^{-3}	4.12×10^{-3}
Total	1.46×10^{-2}	2.41×10^{-2}	2.64×10^{-2}	1.64×10^{-2}	1.62×10^{-2}	6.17×10^{-1}	1.55×10^{-2}	9.79×10^{-2}
TEENAGER								
Plume immersion	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	1.89×10^{-4}	8.54×10^{-2}
Ground plane	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	2.19×10^{-4}
Vegetation ingestion	7.24×10^{-3}	9.51×10^{-3}	1.41×10^{-2}	7.12×10^{-3}	7.48×10^{-3}	3.88×10^{-1}	6.43×10^{-3}	6.42×10^{-3}
Meat ingestion	6.02×10^{-4}	5.80×10^{-3}	8.56×10^{-4}	5.86×10^{-4}	7.95×10^{-4}	7.12×10^{-3}	5.78×10^{-4}	5.78×10^{-4}
Milk ingestion	2.69×10^{-3}	2.60×10^{-3}	2.01×10^{-3}	2.67×10^{-3}	2.70×10^{-3}	7.47×10^{-2}	2.58×10^{-3}	2.57×10^{-3}
Inhalation	4.59×10^{-3}	4.16×10^{-3}	1.43×10^{-2}	7.03×10^{-3}	6.25×10^{-3}	4.82×10^{-3}	6.27×10^{-3}	4.15×10^{-3}
Total	1.60×10^{-2}	2.29×10^{-2}	3.21×10^{-2}	1.83×10^{-2}	1.81×10^{-2}	4.75×10^{-1}	1.79×10^{-2}	9.93×10^{-2}
CHILD								
Plume immersion	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	1.89×10^{-4}	8.54×10^{-2}
Ground plane	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	2.19×10^{-4}
Vegetation ingestion	1.17×10^{-2}	1.30×10^{-2}	3.01×10^{-2}	1.17×10^{-2}	1.23×10^{-2}	3.74×10^{-1}	1.06×10^{-2}	1.06×10^{-2}
Meat ingestion	8.27×10^{-4}	3.97×10^{-3}	1.60×10^{-3}	8.04×10^{-4}	1.08×10^{-3}	5.65×10^{-3}	7.94×10^{-4}	7.93×10^{-4}
Milk ingestion	4.84×10^{-3}	4.38×10^{-3}	4.85×10^{-3}	4.53×10^{-3}	4.57×10^{-3}	7.51×10^{-2}	4.37×10^{-3}	4.36×10^{-3}
Inhalation	4.02×10^{-3}	3.67×10^{-3}	1.13×10^{-2}	5.78×10^{-3}	5.08×10^{-3}	4.07×10^{-3}	5.57×10^{-3}	3.67×10^{-3}
Total	2.19×10^{-2}	2.59×10^{-2}	4.87×10^{-2}	2.37×10^{-2}	2.39×10^{-2}	4.60×10^{-1}	2.34×10^{-2}	1.05×10^{-1}

Table B-16. Annual dose to maximally exposed individual resulting from atmospheric releases from L-Reactor support facilities in tenth year^a (In millirems per year) (continued)

TC

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	7.11×10^{-4}	1.89×10^{-3}	8.54×10^{-2}
Ground plane	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	1.52×10^{-4}	2.19×10^{-4}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	7.31×10^{-3}	7.12×10^{-3}	9.12×10^{-3}	7.49×10^{-3}	7.46×10^{-3}	1.79×10^{-1}	7.11×10^{-3}	7.10×10^{-3}
Inhalation	2.25×10^{-3}	2.11×10^{-3}	4.50×10^{-3}	2.95×10^{-3}	2.67×10^{-3}	2.48×10^{-3}	3.30×10^{-3}	2.11×10^{-3}
Total	1.04×10^{-2}	1.01×10^{-2}	1.45×10^{-2}	1.13×10^{-2}	1.10×10^{-2}	1.83×10^{-1}	1.25×10^{-2}	9.48×10^{-2}

^aIn the support facilities, only the doses resulting from L-Reactor operation are included.

TC

Table B-17. Eighty-kilometer population dose resulting from atmospheric releases from operation of L-Reactor support facilities in first or tenth year^a (In person-rems per year)

TC

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.48×10^{-1}	1.48×10^{-1}	1.48×10^{-1}	1.48×10^{-1}	1.48×10^{-1}	1.48×10^{-1}	4.89×10^{-1}	2.46×10^1
Ground plane	1.85×10^{-1}	1.85×10^{-1}	1.85×10^{-1}	1.85×10^{-1}	1.85×10^{-1}	1.85×10^{-1}	1.85×10^{-1}	2.91×10^{-1}
Vegetation ingestion	8.90×10^{-1}	9.91×10^{-1}	1.49	8.40×10^{-1}	8.98×10^{-1}	8.18×10^1	7.58×10^{-1}	7.56×10^{-1}
Meat ingestion	1.59×10^{-1}	1.00	2.03×10^{-1}	1.54×10^{-1}	1.86×10^{-1}	3.64	1.51×10^{-1}	1.51×10^{-1}
Milk ingestion	2.11×10^{-1}	2.00×10^{-1}	1.73×10^{-1}	2.08×10^{-1}	2.11×10^{-1}	8.40	2.00×10^{-1}	1.99×10^{-1}
Inhalation	1.21	1.10	3.74	1.84	1.64	1.31	1.51	1.10
Total	2.80	3.63	5.94	3.38	3.26	9.55×10^1	3.30	2.71×10^1

^aIn the support facilities, only the doses resulting from L-Reactor operation are included.

TC

only, results are shown for the first- and tenth-year operation, as well as for operation with and without the use of the L-Area seepage basin. For support facility doses, maximum-individual doses are shown for the first and tenth year; the population dose will not change significantly between the first and tenth year.

Atmospheric releases containing tritium, carbon-14, krypton-85, and iodine-129 that will be released from L-Reactor and its support facilities will persist in the environment for long periods, and will be transported long distances. The population beyond 80 kilometers from the Savannah River Plant can receive radiation doses from these nuclides. Environmental transport and dose models have been adapted for each of these nuclides for this analysis. For each nuclide, the 100-year environmental dose commitment has been calculated. A constant U.S. population of 250 million for the year 2000 has been assumed (NCRP, 1975, 1979; Kocher, 1979; Killough, 1980). Table B-18 lists the results of these calculations.

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B.2 LIQUID RELEASES

The LADTAP II computer code (Simpson and McGill, 1980) was used to calculate radiation exposures due to liquid releases; LADTAP II implements the dose models recommended in NRC Regulatory Guide 1.109 (NRC, 1977). Both maximum-individual and population doses were calculated as functions of age group and pathway for the total body and appropriate body organs. Age-specific dose conversion factors were used for converting internal exposures to doses. The dose conversion factors are based on NUREG-0172 (Hoenes and Soldat, 1977), with revisions for some radionuclides (Simpson and McGill, 1980); the age groups considered were the same as those used for the atmospheric release calculations. The exposure to external radiation is the same for all age groups.

During routine operation of L-Reactor and its support facilities, radioactive materials will be discharged both to surface streams and to seepage basins. In this analysis, two alternatives have been considered for the discharge of L-Reactor liquid radioactive effluent. The first alternative is discharge both to Steel Creek and to the existing L-Reactor seepage basin and the second alternative is discharge directly to Steel Creek. All radioactive materials discharged from facility operations to surface streams ultimately discharge into the Savannah River. Radioactive materials discharged to seepage basins will move down to the ground water; gradually they will be transported laterally to outcrop areas along surface streams. After ground water containing radionuclides emerges at these outcrops, it is discharged to the Savannah River. Table B-19 lists ground-water velocities and the distances between the various seepage basins and their respective outcrops for operations associated with L-Reactor. The model for radionuclide transport in ground water uses a one-dimensional analytic solution for the mass transport of radionuclides and their decay products (Burkholder and Rosinger, 1979). Dispersion in the direction of travel was assumed to be zero. Some radioactive decay will occur during transit, thereby reducing the dose. The transport of nuclides can also be impeded by chemical interactions and the adsorptive and absorptive properties of the geologic media through which ground water flows. Radionuclide activities at the outcrops were simulated for periods as long as 39,000 years. This period was

Table B-18. 100-year environmental dose commitment to the U.S. population beyond 80 kilometers of Savannah River Plant from gaseous effluents from L-Reactor and its support facilities

Nuclide	Curies released per year of operation	Person-rem per year of operation	Organ
L-REACTOR WITH SEEPAGE BASIN (FIRST YEAR)			
H-3	5,490	2.57	Total body
C-14	12	8.40	Total body
Kr-85	138	2.76×10^{-3}	Total body
I-129	0	0	Thyroid
L-REACTOR WITH SEEPAGE BASIN (TENTH YEAR)			
H-3	54,900	25.7	Total body
C-14	12	8.40	Total body
Kr-85	138	2.76×10^{-3}	Total body
I-129	0	0	Thyroid
L-REACTOR WITHOUT SEEPAGE BASIN (FIRST YEAR)			
H-3	5,170	2.42	Total body
C-14	12	8.40	Total body
Kr-85	138	2.76×10^{-3}	Total body
I-129	0	0	Thyroid
L-REACTOR WITHOUT SEEPAGE BASIN (TENTH YEAR)			
H-3	51,700	24.2	Total body
C-14	12	8.40	Total body
Kr-85	138	2.76×10^{-3}	Total body
I-129	0	0	Thyroid
SUPPORT FACILITIES			
H-3	9,390	4.39	Total body
C-14	8	5.60	Total body
Kr-85	201,800	4.04	Total body
I-129	0.07	1.73	Thyroid

Table B-19. Ground-water migration data for seepage basins

Parameter	L-Area (100-L)	Central shops (690-G)	Fuel fabri- cation (300-M)	Separations areas	
				200-F	200-H
Ground-water velocity (m/day) ^a	0.3 ^b	0.3	0.3	0.2	0.3
Distance to outcrop (m)	490	365	1220	490	120-425
Ground-water travel time (yr)	4.4	3.3	^b	6.7 ^c	1.1-3.8 ^c

^aBased on Du Pont, 1983b.

^bAssumed lateral ground-water velocity of 0.3 meter per day used in dose calculations; based on Root (1983) and Section F.2.10, a more realistic ground-water velocity is calculated to be 0.075 to 0.057 meter per day.

^c3.8 years has been assumed for both the 200-F and 200-H areas.

TC

chosen so all nuclides (even those with retarded movement) emerged at the outcrop. However, liquid radioactive releases from this pathway reduce to insignificant levels after the L-Reactor operation period.

Liquid radioactive release source terms for L-Reactor are given in Table 4-9 for both first- and tenth-year operation. Source terms for the support facilities are given as annual average quantities discharged directly to surface streams, and to surface streams from seepage-basin/ground-water migration (Tables 5-8 through 5-10).

TC

The following pathways and their descriptions were considered in the liquid dose assessments:

1. Drinking water--Internal dose from consumption of drinking water from the Savannah River and containing radioactive materials transported by the river.
2. Sport and commercial fish--Internal dose from consumption of fish of Savannah River origin.
3. Salt-water invertebrates--Internal dose from consumption of shellfish from estuaries of the Savannah River.
4. Recreation--External dose from recreational activities on and along the Savannah River; that is, shoreline activities, boating, and swimming.

All individual and population doses were based on the assumption that liquids discharged from L-Reactor and its support facilities are mixed completely in the river before reaching the potential exposure pathways. This assumption is supported by measurements that indicate complete mixing occurs prior to reaching the Highway 301 bridge. A dilution factor of 3 was applied to the

shellfish dose calculation because a significant portion of the harvest would be from estuarine or ocean waters.

TC

Individual and site parameters used in the calculations are summarized in Tables B-20 and B-21, respectively. The data on fish consumption, swimming, and boating are based on data from the region.

The individual who would receive the maximum potential dose from liquid releases was assumed to live near the Savannah River, downstream from the Savannah River Plant. This individual was assumed to use river water regularly for drinking, to consume river fish, and to receive external exposure from shoreline activities, swimming, and boating.

The total dose received by the offsite population as a result of liquid releases from L-Reactor and its support facilities is estimated by summing the doses to the individuals in the population. The population within an 80-kilometer radius uses no river water for domestic purposes downstream from Savannah River Plant; this population is assumed to use the river for recreational purposes and to consume fish and shellfish from the river and its estuary.

There is no known use of Savannah River water for human consumption to a distance of about 160 kilometers downstream from Savannah River Plant. At this distance, Beaufort and Jasper Counties, South Carolina, will pump water from the river for treatment and service to a population of about 117,000 people in the year 2000. Several kilometers farther downstream, the Cherokee Hill Water Treatment Plant draws water from the river to supply a business-industrial complex near Savannah, Georgia. This water is not used at present for normal domestic service, but it is assumed that about 200,000 people will use this water during the year 2000. Although these population groups are beyond the 80-kilometer radius, drinking-water doses for these groups have been included in this document. All population doses are 100-year environmental dose commitments.

The results of the calculations of doses to the maximally exposed individual and to populations from liquid radioactive releases from L-Reactor and its support facilities are presented in Tables B-22 through B-33. Maximum individual and population doses due to L-Reactor liquid radioactive releases for the first year, and after the tenth year, are presented in Tables B-22 through B-25 for the seepage-basin alternative. Similar results are presented in Tables B-26 through B-29 for the no-seepage-basin alternative. Results for the support facilities are presented in Tables B-30 through B-33. These results are not affected by the seepage-basin alternative used; they are presented as releases directly to surface streams and to streams by the seepage-basin/ground-water pathway.

B.3 RADIOACTIVE CESIUM AND COBALT REDISTRIBUTION

3

The reactivation of L-Reactor will cause a portion of the radioactive cesium and cobalt in the Steel Creek channel and floodplain to be resuspended and transported for both the reference case (defined in this appendix) and the

Table B-20. Individual parameters used in dose calculations

Parameters	Child	Teen	Adult
AVERAGE INDIVIDUAL			
Water consumption (ℓ/year)	260	260	370
Fish consumption (kg/yr)	3.6	8.5	11.3
Other seafood consumption (kg/yr)	0.33	0.75	1.0
Shoreline recreation (hr/yr)	9.5	47	8.3
Boating (person-hours) ^a	--	--	700,000
Swimming (person-hours) ^a	--	--	100,000
Shoreline recreation (person-hours) ^a	--	--	200,000
MAXIMUM INDIVIDUAL			
Water consumption (ℓ/yr) ^b	510	510	730
Fish consumption (kg/yr)	11.2	25.9	34
Other seafood consumption (kg/yr)	1.7	3.8	5
Shoreline recreation (hr/yr)	14	67	20
Swimming (hr/yr)	10	10	10
Boating (hr/yr)	60	60	60

^aFor population dose calculations.^bDrinking water consumption for an infant equals 330 liters per year.

Table B-21. Site parameters used in dose calculations

Parameters	Values
River flow rate (average m ³ /s)	294
(low flow m ³ /s)	173
River dilution in estuary	3
Transit time, L-Area to river (hr)	24
Transit time, SRP to water treatment plants (hr)	72
Water treatment time (hr)	24
Aquatic food harvest (kg/yr)	
Fish - sport	90,700
Fish - commercial	31,800
Invertebrates - salt water	299,000
Irrigation	None
Shore width factor	0.2
Population in year 2000 ^a	
Beaufort-Jasper water consumers	117,000
Port Wentworth water consumers	200,000
80-kilometer-radius population	852,000

^aAge distribution of population: Beaufort-Jasper--21 percent child, 10 percent teen, 69 percent adult; Port Wentworth--100 percent adult; and 80-kilometer radius--21 percent child, 11 percent teen, 68 percent adult.

Table B-22. Annual dose to maximally exposed individual resulting from liquid releases from L-Reactor with seepage basin in first year (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	1.05×10^{-1}	6.32×10^{-4}	2.60×10^{-3}	1.24×10^{-4}	2.91×10^{-4}	1.80×10^{-4}	3.11×10^{-3}
Drinking	0.0	7.53×10^{-2}	2.98×10^{-3}	4.50×10^{-3}	2.97×10^{-3}	2.97×10^{-3}	2.97×10^{-3}	5.00×10^{-3}
Shoreline	6.32×10^{-5}	5.37×10^{-5}	5.37×10^{-5}	5.37×10^{-5}	5.37×10^{-5}	5.37×10^{-5}	5.37×10^{-5}	5.37×10^{-5}
Swimming	0.0	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}
Boating	0.0	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}
Total	6.32×10^{-5}	1.81×10^{-1}	3.67×10^{-3}	7.15×10^{-3}	3.15×10^{-3}	3.32×10^{-3}	3.20×10^{-3}	8.17×10^{-3}
TEENAGER								
Fish	0.0	9.05×10^{-2}	6.11×10^{-4}	2.10×10^{-3}	9.20×10^{-5}	2.59×10^{-4}	1.57×10^{-4}	2.38×10^{-3}
Drinking	0.0	6.16×10^{-2}	2.10×10^{-3}	3.34×10^{-3}	2.09×10^{-3}	2.09×10^{-3}	2.09×10^{-3}	3.59×10^{-3}
Shoreline	2.12×10^{-4}	1.80×10^{-4}	1.80×10^{-4}	1.80×10^{-4}	1.80×10^{-4}	1.88×10^{-4}	1.80×10^{-4}	1.80×10^{-4}
Swimming	0.0	2.23×10^{-7}	2.37×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}
Boating	0.0	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}
Total	2.12×10^{-4}	1.52×10^{-1}	2.88×10^{-3}	5.63×10^{-3}	2.37×10^{-3}	2.53×10^{-3}	2.43×10^{-3}	6.15×10^{-3}
CHILD								
Fish	0.0	1.02×10^{-1}	5.57×10^{-4}	2.24×10^{-3}	7.92×10^{-5}	2.30×10^{-4}	1.34×10^{-4}	1.07×10^{-3}
Drinking	0.0	1.55×10^{-1}	4.03×10^{-3}	7.16×10^{-3}	4.01×10^{-3}	4.01×10^{-3}	4.01×10^{-3}	5.46×10^{-3}
Shoreline	4.42×10^{-5}	3.76×10^{-5}	3.76×10^{-5}	3.76×10^{-5}	3.76×10^{-5}	3.76×10^{-5}	3.76×10^{-5}	3.76×10^{-5}
Swimming	0.0	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}	2.23×10^{-7}
Boating	0.0	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}	6.69×10^{-7}
Total	4.42×10^{-5}	2.57×10^{-1}	4.63×10^{-3}	9.43×10^{-3}	4.13×10^{-3}	4.28×10^{-3}	4.18×10^{-3}	6.57×10^{-3}

Table B-22. Annual dose to maximally exposed individual resulting from liquid releases from
L-Reactor with seepage basin in first year (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	1.11×10^{-1}	3.96×10^{-3}	6.22×10^{-3}	3.94×10^{-3}	3.94×10^{-3}	3.94×10^{-3}	4.88×10^{-3}
Total	0.0	1.11×10^{-1}	3.96×10^{-3}	6.22×10^{-3}	3.94×10^{-3}	3.94×10^{-3}	3.94×10^{-3}	4.88×10^{-3}

Table B-23. Annual dose to maximally exposed individual resulting from liquid releases from L-Reactor with seepage basin in tenth year (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	1.05×10^{-1}	3.83×10^{-3}	5.79×10^{-3}	3.32×10^{-3}	3.48×10^{-3}	3.37×10^{-3}	6.30×10^{-3}
Drinking	0.0	7.53×10^{-2}	7.92×10^{-2}	8.07×10^{-2}	7.92×10^{-2}	7.92×10^{-2}	7.92×10^{-2}	8.12×10^{-2}
Shoreline	6.36×10^{-5}	5.41×10^{-5}	5.41×10^{-5}	5.41×10^{-5}	5.41×10^{-5}	5.41×10^{-5}	5.41×10^{-5}	5.41×10^{-5}
Swimming	0.0	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}
Boating	0.0	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}
Total	6.36×10^{-5}	1.81×10^{-1}	8.30×10^{-2}	8.65×10^{-2}	8.25×10^{-2}	8.27×10^{-2}	8.26×10^{-2}	8.76×10^{-2}
TEENAGER								
Fish	0.0	9.05×10^{-2}	2.96×10^{-3}	4.47×10^{-3}	2.45×10^{-3}	2.62×10^{-3}	2.52×10^{-3}	4.74×10^{-3}
Drinking	0.0	6.16×10^{-2}	5.58×10^{-2}	5.71×10^{-2}	5.58×10^{-2}	5.58×10^{-2}	5.58×10^{-2}	5.73×10^{-2}
Shoreline	2.13×10^{-4}	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}	1.81×10^{-4}
Swimming	0.0	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}
Boating	0.0	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}
Total	2.13×10^{-4}	1.52×10^{-1}	5.90×10^{-2}	6.17×10^{-2}	5.85×10^{-2}	5.86×10^{-2}	5.85×10^{-2}	6.23×10^{-2}
CHILD								
Fish	0.0	1.02×10^{-1}	2.59×10^{-3}	4.27×10^{-3}	2.11×10^{-3}	2.26×10^{-3}	2.17×10^{-3}	3.11×10^{-3}
Drinking	0.0	1.55×10^{-1}	1.07×10^{-1}	1.10×10^{-1}	1.07×10^{-1}	1.07×10^{-1}	1.07×10^{-1}	1.08×10^{-1}
Shoreline	4.45×10^{-5}	3.78×10^{-5}	3.78×10^{-5}	3.78×10^{-5}	3.78×10^{-5}	3.78×10^{-5}	3.78×10^{-5}	3.78×10^{-5}
Swimming	0.0	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}	2.25×10^{-7}
Boating	0.0	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}	6.76×10^{-7}
Total	4.45×10^{-5}	2.57×10^{-1}	1.10×10^{-1}	1.14×10^{-1}	1.09×10^{-1}	1.09×10^{-1}	1.09×10^{-1}	1.12×10^{-1}

Table B-23. Annual dose to maximally exposed individual resulting from liquid releases from L-Reactor with seepage basin in tenth year (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	1.11×10^{-1}	1.05×10^{-1}	1.07×10^{-1}	1.05×10^{-1}	1.05×10^{-1}	1.05×10^{-1}	1.06×10^{-1}
Total	0.0	1.11×10^{-1}	1.05×10^{-1}	1.07×10^{-1}	1.05×10^{-1}	1.05×10^{-1}	1.05×10^{-1}	1.06×10^{-1}

Table B-24. Population dose resulting from liquid releases from operation of L-Reactor with seepage basin in first year (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	5.35	1.84×10^{-1}	2.93×10^{-1}	1.84×10^{-1}	1.84×10^{-1}	1.84×10^{-1}	2.95×10^{-1}
Port Wentworth	0.0	7.60	3.01×10^{-1}	4.55×10^{-1}	3.01×10^{-1}	3.01×10^{-1}	3.01×10^{-1}	5.06×10^{-1}
Total	0.0	1.30×10^1	4.85×10^{-1}	7.48×10^{-1}	4.85×10^{-1}	4.85×10^{-1}	4.85×10^{-1}	8.01×10^{-1}
Sport fish	0.0	3.25×10^{-1}	1.93×10^{-3}	7.76×10^{-3}	3.51×10^{-4}	8.66×10^{-4}	5.28×10^{-4}	8.22×10^{-3}
Commercial fish	0.0	1.89×10^{-2}	1.12×10^{-4}	4.52×10^{-4}	2.04×10^{-5}	5.04×10^{-5}	3.07×10^{-5}	4.78×10^{-4}
Shellfish	0.0	3.77×10^{-4}	2.51×10^{-6}	1.26×10^{-5}	6.32×10^{-7}	6.45×10^{-7}	6.35×10^{-7}	3.79×10^{-5}
Shoreline	6.32×10^{-4}	0.0	0.0	5.37×10^{-4}	5.37×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	2.23×10^{-6}	2.23×10^{-6}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	7.81×10^{-6}	7.81×10^{-6}	0.0	0.0	0.0
Total	6.32×10^{-4}	3.44×10^{-1}	2.04×10^{-3}	8.77×10^{-3}	9.19×10^{-4}	9.17×10^{-4}	5.59×10^{-4}	8.74×10^{-3}
Grand total	6.32×10^{-4}	1.33×10^1	4.87×10^{-1}	7.57×10^{-1}	4.86×10^{-1}	4.86×10^{-1}	4.86×10^{-1}	8.10×10^{-1}

Table B-25. Population dose resulting from liquid releases from operation of L-Reactor with seepage basin in tenth year (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	5.35	4.89	5.01	4.89	4.89	4.89	5.01
Port Wentworth	0.0	7.60	8.01	8.15	8.01	8.01	8.01	8.22
Total	0.0	1.30×10^1	1.29×10^1	1.32×10^1	1.29×10^1	1.29×10^1	1.29×10^1	1.32×10^1
Sport fish	0.0	3.25×10^{-1}	1.09×10^{-2}	1.68×10^{-2}	9.35×10^{-3}	9.86×10^{-3}	9.53×10^{-3}	1.72×10^{-2}
Commercial fish	0.0	1.89×10^{-2}	6.36×10^{-4}	9.75×10^{-4}	5.44×10^{-4}	5.74×10^{-4}	5.54×10^{-4}	1.00×10^{-3}
Shellfish	0.0	3.77×10^{-4}	1.87×10^{-5}	2.88×10^{-5}	1.69×10^{-5}	1.69×10^{-5}	1.69×10^{-5}	5.49×10^{-5}
Shoreline	6.36×10^{-4}	0.0	0.0	5.41×10^{-4}	5.41×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	2.25×10^{-6}	2.25×10^{-6}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	7.89×10^{-6}	7.89×10^{-6}	0.0	0.0	0.0
Total	6.36×10^{-4}	3.44×10^{-1}	1.16×10^{-2}	1.84×10^{-2}	1.05×10^{-2}	1.05×10^{-2}	1.01×10^{-2}	1.83×10^{-2}
Grand total	6.36×10^{-4}	1.33×10^1	1.29×10^1	1.32×10^1	1.29×10^1	1.29×10^1	1.29×10^1	1.32×10^1

Table B-26. Annual dose to maximally exposed individual resulting from liquid releases from L-Reactor without seepage basin in first year (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	3.12×10^{-1}	6.51×10^{-2}	4.66×10^{-2}	1.14×10^{-3}	2.08×10^{-2}	7.27×10^{-3}	1.56×10^{-2}
Drinking	0.0	1.37×10^{-1}	1.28×10^{-2}	1.54×10^{-2}	1.33×10^{-2}	1.25×10^{-2}	1.24×10^{-2}	1.63×10^{-2}
Shoreline	9.77×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}
Swimming	0.0	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.0	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	9.77×10^{-5}	4.49×10^{-1}	7.80×10^{-2}	6.21×10^{-2}	1.45×10^{-2}	3.34×10^{-2}	1.98×10^{-2}	3.20×10^{-2}
TEEN								
Fish	0.0	2.90×10^{-1}	6.53×10^{-2}	2.77×10^{-2}	9.41×10^{-4}	2.08×10^{-2}	8.30×10^{-3}	1.21×10^{-2}
Drinking	0.0	1.12×10^{-1}	9.14×10^{-3}	1.11×10^{-2}	9.52×10^{-3}	8.87×10^{-3}	8.78×10^{-3}	1.16×10^{-2}
Shoreline	3.27×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}
Swimming	0.0	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.0	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	3.27×10^{-4}	4.02×10^{-1}	7.47×10^{-2}	3.91×10^{-2}	1.07×10^{-2}	2.99×10^{-2}	1.74×10^{-2}	2.40×10^{-2}
CHILD								
Fish	0.0	3.53×10^{-1}	6.20×10^{-2}	1.66×10^{-2}	9.31×10^{-4}	1.88×10^{-2}	6.93×10^{-3}	5.45×10^{-3}
Drinking	0.0	2.82×10^{-1}	1.76×10^{-2}	2.25×10^{-2}	1.86×10^{-2}	1.70×10^{-2}	1.68×10^{-2}	1.95×10^{-2}
Shoreline	6.84×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}
Swimming	0.00	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.00	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	6.84×10^{-5}	6.34×10^{-1}	7.96×10^{-2}	3.92×10^{-2}	1.96×10^{-2}	3.58×10^{-2}	2.38×10^{-2}	2.50×10^{-2}

Table B-26. Annual dose to maximally exposed individual resulting from liquid releases from
L-Reactor without seepage basin in first year (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	2.02×10^{-1}	1.75×10^{-2}	2.06×10^{-2}	1.94×10^{-2}	1.67×10^{-2}	1.65×10^{-2}	1.82×10^{-2}
Total	0.0	2.02×10^{-1}	1.75×10^{-2}	2.06×10^{-2}	1.94×10^{-2}	1.67×10^{-2}	1.65×10^{-2}	1.82×10^{-2}

Table B-27. Annual dose to maximally exposed individual resulting from liquid releases from L-Reactor without seepage basin in tenth year (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	3.12×10^{-1}	6.98×10^{-2}	5.13×10^{-2}	5.81×10^{-3}	2.55×10^{-2}	1.19×10^{-2}	2.03×10^{-2}
Drinking	0.0	1.37×10^{-1}	1.24×10^{-1}	1.27×10^{-1}	1.25×10^{-1}	1.24×10^{-1}	1.24×10^{-1}	1.28×10^{-1}
Shoreline	9.77×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}	8.33×10^{-5}
Swimming	0.0	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.0	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	9.77×10^{-5}	4.49×10^{-1}	1.94×10^{-1}	1.78×10^{-1}	1.30×10^{-1}	1.49×10^{-1}	1.36×10^{-1}	1.48×10^{-1}
TEEN								
Fish	0.0	2.90×10^{-1}	6.87×10^{-2}	3.12×10^{-2}	4.39×10^{-3}	2.42×10^{-2}	1.17×10^{-2}	1.55×10^{-2}
Drinking	0.0	1.12×10^{-1}	8.77×10^{-2}	8.96×10^{-2}	8.80×10^{-2}	8.74×10^{-2}	8.73×10^{-2}	9.01×10^{-2}
Shoreline	3.27×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}	2.79×10^{-4}
Swimming	0.0	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.0	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	3.27×10^{-4}	4.02×10^{-1}	1.57×10^{-1}	1.21×10^{-1}	9.27×10^{-2}	1.12×10^{-1}	9.93×10^{-2}	1.06×10^{-1}
CHILD								
Fish	0.0	3.53×10^{-1}	6.50×10^{-2}	1.96×10^{-2}	3.90×10^{-3}	2.17×10^{-2}	9.94×10^{-3}	8.42×10^{-3}
Drinking	0.0	2.82×10^{-1}	1.68×10^{-1}	1.73×10^{-1}	1.69×10^{-1}	1.67×10^{-1}	1.67×10^{-1}	1.70×10^{-1}
Shoreline	6.84×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}	5.83×10^{-5}
Swimming	0.0	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}	3.18×10^{-7}
Boating	0.0	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}	9.53×10^{-7}
Total	6.84×10^{-5}	6.34×10^{-1}	2.33×10^{-1}	1.93×10^{-1}	1.73×10^{-1}	1.89×10^{-1}	1.77×10^{-1}	1.78×10^{-1}

Table B-27. Annual dose to maximally exposed individual resulting from liquid releases from
L-Reactor without seepage basin in tenth year (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	2.02×10^{-1}	1.65×10^{-1}	1.68×10^{-1}	1.67×10^{-1}	1.64×10^{-1}	1.64×10^{-1}	1.66×10^{-1}
Total	0.0	2.02×10^{-1}	1.65×10^{-1}	1.68×10^{-1}	1.67×10^{-1}	1.64×10^{-1}	1.64×10^{-1}	1.66×10^{-1}

Table B-28. Population dose resulting from liquid releases from operation of L-Reactor without seepage basin in first year (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	9.79	7.96×10^{-1}	9.79×10^{-1}	8.19×10^{-1}	7.75×10^{-1}	7.70×10^{-1}	9.79×10^{-1}
Port Wentworth	0.0	1.39×10^1	1.29	1.56	1.33	1.27	1.25	1.65
Total	0.0	2.37×10^1	2.09	2.54	2.15	2.05	2.02	2.63
Sport fish	0.0	9.15×10^{-1}	1.98×10^{-1}	1.17×10^{-1}	2.42×10^{-3}	6.43×10^{-2}	2.31×10^{-2}	3.39×10^{-2}
Commercial fish	0.0	5.19×10^{-2}	1.15×10^{-2}	6.77×10^{-3}	1.28×10^{-4}	3.74×10^{-3}	1.34×10^{-3}	1.85×10^{-3}
Shellfish	0.0	7.70×10^{-4}	1.21×10^{-5}	2.53×10^{-5}	6.98×10^{-6}	3.73×10^{-6}	2.97×10^{-6}	9.48×10^{-5}
Shoreline	9.77×10^{-4}	0.0	0.0	8.33×10^{-4}	8.33×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	3.18×10^{-6}	3.18×10^{-6}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	1.11×10^{-5}	1.11×10^{-5}	0.0	0.0	0.0
Total	9.77×10^{-4}	9.68×10^{-1}	2.09×10^{-1}	1.25×10^{-1}	3.40×10^{-3}	6.80×10^{-2}	2.44×10^{-2}	3.58×10^{-2}
Grand total	9.77×10^{-4}	2.47×10^1	2.30	2.67	2.15	2.12	2.04	2.67

Table B-29. Population dose resulting from liquid releases from operation of L-Reactor without seepage basin in tenth year (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	9.79	7.70	7.88	7.70	7.68	7.68	7.88
Port Wentworth	0.0	1.39×10^1	1.25×10^1	1.28×10^1	1.26×10^1	1.25×10^1	1.25×10^1	1.29×10^1
Total	0.0	2.37×10^1	2.02×10^1	2.07×10^1	2.03×10^1	2.02×10^1	2.02×10^1	2.08×10^1
Sport fish	0.0	9.15×10^{-1}	2.11×10^{-1}	1.30×10^{-1}	1.56×10^{-2}	7.74×10^{-2}	3.62×10^{-2}	4.71×10^{-2}
Commercial fish	0.0	5.19×10^{-2}	1.22×10^{-2}	7.53×10^{-3}	8.93×10^{-4}	4.50×10^{-3}	2.11×10^{-3}	2.62×10^{-3}
Shellfish	0.0	7.70×10^{-4}	3.58×10^{-5}	4.90×10^{-5}	3.07×10^{-5}	2.74×10^{-5}	2.67×10^{-5}	1.18×10^{-4}
Shoreline	9.77×10^{-4}	0.0	0.0	8.33×10^{-4}	8.33×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	3.18×10^{-6}	3.18×10^{-6}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	1.11×10^{-5}	1.11×10^{-5}	0.0	0.0	0.0
Total	9.77×10^{-4}	9.67×10^{-1}	2.23×10^{-1}	1.38×10^{-1}	1.74×10^{-2}	8.19×10^{-2}	3.83×10^{-2}	4.98×10^{-2}
Grand total	9.77×10^{-4}	2.47×10^1	2.04×10^1	2.08×10^1	2.03×10^1	2.03×10^1	2.02×10^1	2.08×10^1

Table B-30. Annual dose to maximally exposed individual resulting from liquid releases from support facilities for L-Reactor in first year^a (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	7.62×10^{-2}	2.29×10^{-2}	1.63×10^{-2}	1.94×10^{-4}	7.98×10^{-3}	2.76×10^{-3}	2.15×10^{-3}
Drinking	0.0	4.58×10^{-2}	4.80×10^{-3}	5.77×10^{-3}	4.62×10^{-3}	5.43×10^{-3}	4.64×10^{-3}	6.01×10^{-3}
Shoreline	4.47×10^{-5}	3.65×10^{-5}	3.65×10^{-5}	3.65×10^{-5}	3.65×10^{-5}	3.65×10^{-5}	3.65×10^{-5}	3.65×10^{-5}
Swimming	0.0	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}
Boating	0.0	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}
Total	4.47×10^{-5}	1.22×10^{-1}	2.78×10^{-2}	2.21×10^{-2}	4.85×10^{-3}	1.34×10^{-2}	7.43×10^{-3}	8.20×10^{-3}
TEEN								
Fish	0.0	6.82×10^{-2}	2.29×10^{-2}	9.10×10^{-3}	1.43×10^{-4}	7.96×10^{-3}	3.15×10^{-3}	1.65×10^{-3}
Drinking	0.0	3.81×10^{-2}	3.43×10^{-3}	4.20×10^{-3}	3.26×10^{-3}	4.06×10^{-3}	3.28×10^{-3}	4.29×10^{-3}
Shoreline	1.50×10^{-4}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-4}	1.22×10^{-4}
Swimming	0.0	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}
Boating	0.0	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}
Total	1.50×10^{-4}	1.06×10^{-1}	2.64×10^{-2}	1.34×10^{-2}	3.52×10^{-3}	1.21×10^{-2}	6.55×10^{-3}	6.06×10^{-3}
CHILD								
Fish	0.0	8.03×10^{-2}	2.16×10^{-2}	4.48×10^{-3}	1.23×10^{-4}	7.20×10^{-3}	2.64×10^{-3}	7.82×10^{-4}
Drinking	0.0	9.70×10^{-2}	6.59×10^{-3}	8.61×10^{-3}	6.24×10^{-3}	7.90×10^{-3}	6.27×10^{-3}	7.25×10^{-3}
Shoreline	3.13×10^{-5}	2.56×10^{-5}	2.56×10^{-5}	2.56×10^{-5}	2.56×10^{-5}	2.56×10^{-5}	2.56×10^{-5}	2.56×10^{-5}
Swimming	0.0	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}	3.50×10^{-8}
Boating	0.0	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}
Total	3.13×10^{-5}	1.77×10^{-1}	2.82×10^{-2}	1.31×10^{-2}	6.39×10^{-3}	1.51×10^{-2}	8.94×10^{-3}	8.06×10^{-3}

Table B-30. Annual dose to maximally exposed individual resulting from liquid releases from support facilities for L-Reactor in first year^a (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	7.11×10^{-2}	6.55×10^{-3}	8.05×10^{-3}	6.12×10^{-3}	8.01×10^{-3}	6.17×10^{-3}	6.78×10^{-3}
Total	0.0	7.11×10^{-2}	6.55×10^{-3}	8.05×10^{-3}	6.12×10^{-3}	8.01×10^{-3}	6.17×10^{-3}	6.78×10^{-3}

^aIn the support facilities, only the doses resulting from L-Reactor operation are included.

Table B-31. Population dose resulting from liquid releases from support facilities for L-Reactor in first year^a (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	3.30	2.98×10^{-1}	3.68×10^{-1}	2.86×10^{-1}	3.45×10^{-1}	2.88×10^{-1}	3.61×10^{-1}
Port Wentworth	0.0	4.64	4.86×10^{-1}	5.84×10^{-1}	4.67×10^{-1}	5.49×10^{-1}	4.69×10^{-1}	6.08×10^{-1}
Total	0.0	7.94	7.84×10^{-1}	9.52×10^{-1}	7.53×10^{-1}	8.94×10^{-1}	7.57×10^{-1}	9.69×10^{-1}
Sport fish	0.0	2.40×10^{-1}	7.14×10^{-2}	4.11×10^{-2}	5.45×10^{-4}	2.46×10^{-2}	8.77×10^{-3}	5.72×10^{-3}
Commercial fish	0.0	1.39×10^{-2}	4.15×10^{-3}	2.39×10^{-3}	3.17×10^{-5}	1.43×10^{-3}	5.10×10^{-4}	3.33×10^{-4}
Shellfish	0.0	2.30×10^{-4}	2.91×10^{-6}	6.52×10^{-6}	9.83×10^{-7}	4.05×10^{-6}	1.10×10^{-6}	6.89×10^{-6}
Shoreline	4.47×10^{-4}	0.0	0.0	3.65×10^{-4}	3.65×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	3.50×10^{-7}	3.50×10^{-7}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	1.23×10^{-6}	1.23×10^{-6}	0.0	0.0	0.0
Total	4.47×10^{-4}	2.54×10^{-1}	7.56×10^{-2}	4.39×10^{-2}	9.44×10^{-4}	2.60×10^{-2}	9.28×10^{-3}	6.06×10^{-3}
Grand total	4.47×10^{-4}	8.19	8.60×10^{-1}	9.96×10^{-1}	7.54×10^{-1}	9.20×10^{-1}	7.66×10^{-1}	9.75×10^{-1}

^aFor the support facilities, only the doses resulting from L-Reactor operation are included.

Table B-32. Annual dose to maximally exposed individual resulting from liquid releases from support facilities in tenth year^a (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	7.63×10^{-2}	2.41×10^{-2}	1.75×10^{-2}	1.30×10^{-3}	9.26×10^{-3}	3.87×10^{-3}	8.11×10^{-3}
Drinking	0.0	4.60×10^{-2}	3.12×10^{-2}	3.22×10^{-2}	3.10×10^{-2}	3.21×10^{-2}	3.10×10^{-2}	4.34×10^{-2}
Shoreline	1.11×10^{-4}	9.28×10^{-5}	9.28×10^{-5}	9.28×10^{-5}	9.28×10^{-5}	9.28×10^{-5}	9.28×10^{-5}	9.28×10^{-5}
Swimming	0.0	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}
Boating	0.0	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}
Total	1.11×10^{-4}	1.22×10^{-1}	5.54×10^{-2}	4.98×10^{-2}	3.24×10^{-2}	4.15×10^{-2}	3.50×10^{-2}	5.16×10^{-2}
TEEN								
Fish	0.0	6.83×10^{-2}	2.38×10^{-2}	9.98×10^{-3}	9.61×10^{-4}	8.96×10^{-3}	3.97×10^{-3}	6.19×10^{-3}
Drinking	0.0	3.83×10^{-2}	2.20×10^{-2}	2.28×10^{-2}	2.19×10^{-2}	2.30×10^{-2}	2.19×10^{-2}	3.11×10^{-2}
Shoreline	3.73×10^{-4}	3.10×10^{-4}	3.10×10^{-4}	3.10×10^{-4}	3.10×10^{-4}	3.10×10^{-4}	3.10×10^{-4}	3.10×10^{-4}
Swimming	0.0	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}
Boating	0.0	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}
Total	3.73×10^{-4}	1.07×10^{-1}	4.61×10^{-2}	3.31×10^{-2}	2.32×10^{-2}	3.23×10^{-2}	2.62×10^{-2}	3.76×10^{-2}
CHILD								
Fish	0.0	8.04×10^{-2}	2.24×10^{-2}	5.26×10^{-3}	8.27×10^{-4}	8.07×10^{-3}	3.34×10^{-3}	3.09×10^{-3}
Drinking	0.0	9.75×10^{-2}	4.23×10^{-2}	4.43×10^{-2}	4.18×10^{-2}	4.41×10^{-2}	4.19×10^{-2}	5.08×10^{-2}
Shoreline	7.79×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}	6.50×10^{-5}
Swimming	0.0	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}	2.12×10^{-7}
Boating	0.0	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}	6.35×10^{-7}
Total	7.79×10^{-5}	1.78×10^{-1}	6.48×10^{-2}	4.96×10^{-2}	4.27×10^{-2}	5.22×10^{-2}	4.53×10^{-2}	5.40×10^{-2}

Table B-32. Annual dose to maximally exposed individual resulting from liquid releases from support facilities in tenth year^a (in millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	--	7.17×10^{-2}	4.16×10^{-2}	4.32×10^{-2}	4.11×10^{-2}	4.37×10^{-2}	4.12×10^{-2}	4.69×10^{-2}
Total	0.0	7.17×10^{-2}	4.16×10^{-2}	4.32×10^{-2}	4.11×10^{-2}	4.37×10^{-2}	4.12×10^{-2}	4.69×10^{-2}

^aFor the support facilities, only the doses resulting from L-Reactor operation are included.

Table B-33. Population dose resulting from liquid releases from support facilities in tenth year^a (In person-rem/s per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	3.30	1.93	2.00	1.93	2.00	1.93	2.59
Port Wentworth	0.0	4.66	3.16	3.25	3.14	3.25	3.14	4.40
Total	0.0	7.96	5.09	5.25	5.07	5.25	5.07	6.99
Sport fish	0.0	2.40×10^{-1}	7.48×10^{-2}	4.44×10^{-2}	3.67×10^{-3}	2.83×10^{-2}	1.19×10^{-2}	2.14×10^{-2}
Commercial fish	0.0	1.39×10^{-2}	4.35×10^{-3}	2.58×10^{-3}	2.13×10^{-4}	1.64×10^{-3}	6.91×10^{-4}	1.25×10^{-3}
Shellfish	0.0	2.74×10^{-4}	1.84×10^{-5}	2.44×10^{-5}	6.60×10^{-6}	8.75×10^{-5}	6.72×10^{-6}	2.23×10^{-3}
Shoreline	1.11×10^{-3}	0.0	0.0	9.28×10^{-4}	9.28×10^{-4}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	2.12×10^{-6}	2.12×10^{-6}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	7.41×10^{-6}	7.41×10^{-6}	0.0	0.0	0.0
Total	1.11×10^{-3}	2.54×10^{-1}	7.92×10^{-2}	4.79×10^{-2}	4.83×10^{-3}	3.00×10^{-2}	1.26×10^{-2}	2.49×10^{-2}
Grand total	1.11×10^{-3}	8.21	5.17	5.30	5.07	5.28	5.08	7.01

^aFor the support facilities, only the doses resulting from L-Reactor operation are included.

TC

preferred cooling-water alternative (doses derived from the reference-case analysis described in this appendix and presented in Appendix L). The methods used to calculate dose commitments from this source were the same as those used for other liquid releases, except a bioaccumulation factor of 3000 was used for cesium in freshwater fish rather than the value of 2000 recommended in NRC Regulatory Guide 1.109 (NRC, 1977). This higher bioaccumulation factor reflects the results of studies of fish from the Savannah River and Steel Creek performed by the Savannah River Laboratory and the Savannah River Ecology Laboratory (Du Pont, 1982; Smith et al., 1982).

Tables B-34 through B-37 list the results of dose calculations (for both average and low river flow) to maximally exposed individuals and to regional populations due to the first year (maximum) radioactive cesium and cobalt transport that results from the resumption of L-Reactor operation.

B.4 CUMULATIVE EFFECTS

The evaluation of the radiological impacts associated with the restart of L-Reactor also has considered the cumulative effects of all nuclear facilities in the affected region. These cumulative effects are summarized in Section 5.2.6 of the main text and the details of the calculated results are presented below.

Nuclear facilities, in addition to L-Reactor and its support facilities, whose impacts have been considered in the cumulative effects, include the following:

- Three production reactors (P, K, and C) onsite at Savannah River Plant and associated support facilities
- The Vogtle Nuclear Generating Station (VNGS) under construction across the Savannah River from the southwest boundary of Savannah River Plant
- The Defense Waste Processing Facility (DWPF) under construction at S-Area on the Savannah River Plant
- The Fuels Material Facility (FMF) under construction at F-Area on the Savannah River Plant

The maximum individual dose and population doses associated with each of these facilities have been calculated. Information necessary for these dose calculations was derived from supporting environmental documentation available for each facility (DOE, 1982a,b; Du Pont, 1983; and Georgia Power Company, 1973).

The results of the dose calculations are presented in Tables B-38 through B-48. The maximum individual and population doses due to the three production reactors and their support facilities presently operating at Savannah River Plant are given in Tables B-38 through B-41. The same information predicted for the VNGS is given in Tables B-42 through B-45. Projected doses for the DWPF and the FMF are included in Tables B-46 through B-48. These latter three tables also present the cumulative doses associated with L-Reactor and its support

Table B-34. First-year dose from radiocesium and cobalt transport (Average river flow rate)

Pathway	Total body	Skin	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
MAXIMUM INDIVIDUAL DOSE (mrem)								
Adult	3.48	3.28×10^{-3}	3.88	5.30	2.83×10^{-3}	1.80	6.01×10^{-1}	1.08×10^{-1}
Teen	1.86	1.10×10^{-2}	4.00	5.31	9.42×10^{-3}	1.81	7.11×10^{-1}	8.66×10^{-2}
Child	7.48×10^{-1}	2.29×10^{-3}	5.28	5.06	1.99×10^{-3}	1.65	5.95×10^{-1}	3.45×10^{-2}
Infant	6.99×10^{-3}	0.0	8.15×10^{-2}	9.55×10^{-2}	0.0	2.56×10^{-2}	1.04×10^{-2}	5.26×10^{-4}
POPULATION DOSE (person-rem)								
Drinking water								
Port Wentworth	5.01×10^{-1}	0.0	5.48×10^{-1}	7.53×10^{-1}	0.0	2.55×10^{-1}	8.49×10^{-2}	9.59×10^{-2}
Beaufort-Jasper	2.94×10^{-1}	0.0	4.45×10^{-1}	5.51×10^{-1}	0.0	1.77×10^{-1}	6.11×10^{-2}	3.22×10^{-1}
Sport fish	8.52	0.0	1.30×10^1	1.64×10^1	0.0	5.53	1.90	2.70×10^{-1}
Commercial fish	4.96×10^{-1}	0.0	7.58×10^{-1}	9.54×10^{-1}	0.0	3.22×10^{-1}	1.11×10^{-1}	1.57×10^{-2}
Shellfish	1.47×10^{-4}	0.0	1.90×10^{-4}	2.49×10^{-4}	0.0	8.03×10^{-5}	2.77×10^{-5}	1.65×10^{-4}
Shoreline	2.81×10^{-2}	3.28×10^{-2}	0.0	0.0	2.81×10^{-2}	0.0	0.0	0.0
Swimming	5.97×10^{-5}	0.0	0.0	0.0	5.97×10^{-5}	0.0	0.0	0.0
Boating	2.09×10^{-4}	0.0	0.0	0.0	2.09×10^{-4}	0.0	0.0	0.0
Total	9.84	3.28×10^{-2}	1.48×10^1	1.87×10^1	2.84×10^{-2}	6.28	2.16	7.04×10^{-1}

Table B-35. First-year dose from radiocesium and cobalt transport (low river flow; 6100 cfs)

Pathway	Total body	Skin	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
MAXIMUM INDIVIDUAL DOSE (mrem)								
Adult	5.92	5.59×10^{-3}	6.61	9.04	4.82×10^{-3}	3.07	1.02	1.84×10^{-1}
Teen	3.17	1.87×10^{-2}	6.81	9.06	1.61×10^{-2}	3.09	1.21	1.48×10^{-1}
Child	1.28	3.91×10^{-3}	9.01	8.62	3.39×10^{-3}	2.81	1.01	5.88×10^{-2}
Infant	1.19×10^{-2}	0.0	1.39×10^{-1}	1.63×10^{-1}	0.0	4.37×10^{-2}	1.77×10^{-2}	8.97×10^{-4}
POPULATION DOSE (person-rem)								
Drinking water								
Port Wentworth	8.56×10^{-1}	0.0	9.38×10^{-1}	1.29	0.0	4.34×10^{-1}	1.45×10^{-1}	1.64×10^{-1}
Beaufort-Jasper	5.00×10^{-1}	0.0	7.59×10^{-1}	9.39×10^{-1}	0.0	3.01×10^{-1}	1.04×10^{-1}	5.51×10^{-1}
Sport fish	1.45×10^1	0.0	2.22×10^1	2.80×10^1	0.0	9.42	3.25	4.61×10^{-1}
Commercial fish	8.45×10^{-1}	0.0	1.29	1.63	0.0	5.48×10^{-1}	1.89×10^{-1}	2.68×10^{-2}
Shellfish	2.52×10^{-4}	0.0	3.24×10^{-4}	4.25×10^{-4}	0.0	1.37×10^{-4}	4.73×10^{-5}	2.82×10^{-4}
Shoreline	4.78×10^{-2}	5.59×10^{-2}	0.0	0.0	4.78×10^{-2}	0.0	0.0	0.0
Swimming	1.02×10^{-4}	0.0	0.0	0.0	1.02×10^{-4}	0.0	0.0	0.0
Boating	3.56×10^{-4}	0.0	0.0	0.0	3.56×10^{-4}	0.0	0.0	0.0
Total	1.67×10^1	5.59×10^{-2}	2.52×10^1	3.19×10^1	4.83×10^{-2}	1.07×10^1	3.69	1.20

Table B-36. Tenth-year dose from radiocesium and cobalt transport (average river flow)

Pathway	Total body	Skin	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
MAXIMUM INDIVIDUAL DOSE (mrem)								
Adult	3.08×10^{-1}	2.71×10^{-4}	3.44×10^{-1}	4.70×10^{-1}	2.34×10^{-4}	1.60×10^{-1}	5.32×10^{-2}	9.41×10^{-3}
Teen	1.65×10^{-1}	9.07×10^{-4}	3.54×10^{-1}	4.71×10^{-1}	7.79×10^{-4}	1.61×10^{-1}	6.29×10^{-2}	7.52×10^{-3}
Child	6.63×10^{-2}	1.89×10^{-4}	4.68×10^{-1}	4.48×10^{-1}	1.64×10^{-4}	1.46×10^{-1}	5.27×10^{-2}	3.00×10^{-3}
Infant	6.07×10^{-4}	0.0	7.23×10^{-3}	8.46×10^{-3}	0.0	2.27×10^{-3}	9.19×10^{-4}	3.37×10^{-5}
POPULATION DOSE (person-rem)								
Drinking water								
Port Wentworth	4.38×10^{-2}	0.0	4.86×10^{-2}	6.66×10^{-2}	0.0	2.25×10^{-2}	7.47×10^{-3}	3.86×10^{-3}
Beaufort-Jasper	2.30×10^{-2}	0.0	3.94×10^{-2}	4.75×10^{-2}	0.0	1.57×10^{-2}	5.42×10^{-3}	1.10×10^{-2}
Sport fish	7.55×10^{-1}	0.0	1.15	1.45	0.0	4.90×10^{-1}	1.69×10^{-1}	2.37×10^{-2}
Commercial fish	4.39×10^{-2}	0.0	6.72×10^{-2}	8.46×10^{-2}	0.0	2.85×10^{-2}	9.82×10^{-3}	1.38×10^{-3}
Shellfish	1.17×10^{-5}	0.0	1.69×10^{-5}	2.15×10^{-5}	0.0	7.14×10^{-6}	2.46×10^{-6}	5.52×10^{-6}
Shoreline	2.32×10^{-3}	2.71×10^{-3}	0.0	0.0	2.32×10^{-3}	0.0	0.0	0.0
Swimming	4.59×10^{-6}	0.0	0.0	0.0	4.59×10^{-6}	0.0	0.0	0.0
Boating	1.61×10^{-5}	0.0	0.0	0.0	1.61×10^{-5}	0.0	0.0	0.0
Total	8.68×10^{-1}	2.71×10^{-3}	1.31	1.65	2.34×10^{-3}	5.57×10^{-1}	1.92×10^{-1}	3.99×10^{-2}

Table B-37. Tenth-year dose from radiocesium and cobalt transport (low river flow)

Pathway	Total body	Skin	Bone	Liver	Thyroid	Kidney	Lung	GI-LLI
MAXIMUM INDIVIDUAL DOSE (mrem)								
Adult	5.25×10^{-1}	4.62×10^{-4}	5.86×10^{-1}	8.01×10^{-1}	3.99×10^{-4}	2.73×10^{-1}	9.07×10^{-2}	1.60×10^{-2}
Teen	2.81×10^{-1}	1.55×10^{-3}	6.04×10^{-1}	8.03×10^{-1}	1.33×10^{-3}	2.74×10^{-1}	1.07×10^{-1}	1.28×10^{-2}
Child	1.13×10^{-1}	3.22×10^{-4}	7.98×10^{-1}	7.64×10^{-1}	2.80×10^{-4}	2.49×10^{-1}	8.98×10^{-2}	5.11×10^{-3}
Infant	1.03×10^{-3}	0.0	1.23×10^{-2}	1.44×10^{-2}	0.0	3.87×10^{-3}	1.57×10^{-3}	5.75×10^{-5}
POPULATION DOSE (person-rem)								
Drinking water								
Port Wentworth	7.47×10^{-2}	0.0	8.29×10^{-2}	1.14×10^{-1}	0.0	3.84×10^{-2}	1.27×10^{-2}	6.59×10^{-3}
Beaufort-Jasper	3.91×10^{-2}	0.0	6.71×10^{-2}	8.10×10^{-2}	0.0	2.66×10^{-2}	9.24×10^{-3}	1.88×10^{-2}
Sport fish	1.29	0.0	1.96	2.47	0.0	8.35×10^{-1}	2.88×10^{-1}	4.04×10^{-2}
Commercial fish	7.48×10^{-2}	0.0	1.15×10^{-1}	1.44×10^{-1}	0.0	4.86×10^{-2}	1.67×10^{-2}	2.35×10^{-3}
Shellfish	1.99×10^{-5}	0.0	2.88×10^{-5}	3.67×10^{-5}	0.0	1.22×10^{-5}	4.19×10^{-6}	9.41×10^{-6}
Shoreline	3.96×10^{-3}	4.62×10^{-3}	--	--	3.96×10^{-3}	--	--	--
Swimming	7.83×10^{-6}	0.0	--	--	7.83×10^{-6}	--	--	--
Boating	2.74×10^{-5}	0.0	--	--	2.74×10^{-5}	--	--	--
Total	1.48	4.62×10^{-3}	2.23	2.81	4.00×10^{-3}	9.49×10^{-1}	3.27×10^{-1}	6.81×10^{-2}

Table B-38. Annual dose to maximally exposed individual resulting from atmospheric releases from current SRP operation with three reactors (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.11×10^{-1}	5.70×10^{-1}
Ground plane	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	1.02×10^{-3}
Vegetation ingestion	3.05×10^{-1}	3.10×10^{-1}	4.93×10^{-2}	3.03×10^{-1}	3.04×10^{-1}	3.07	3.01×10^{-1}	3.01×10^{-1}
Meat ingestion	4.64×10^{-2}	7.83×10^{-2}	1.19×10^{-2}	4.63×10^{-2}	4.73×10^{-2}	1.39×10^{-1}	4.62×10^{-2}	4.62×10^{-2}
Milk ingestion	1.06×10^{-1}	1.06×10^{-1}	1.29×10^{-2}	1.06×10^{-1}	1.06×10^{-1}	5.72×10^{-1}	1.06×10^{-1}	1.06×10^{-1}
Inhalation	2.50×10^{-1}	2.48×10^{-1}	5.00×10^{-2}	2.57×10^{-1}	2.55×10^{-1}	2.52×10^{-1}	2.53×10^{-1}	2.48×10^{-1}
Total	8.14×10^{-1}	8.48×10^{-1}	2.30×10^{-1}	8.19×10^{-1}	8.19×10^{-1}	4.14	8.18×10^{-1}	1.27
TEENAGER								
Plume immersion	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.11×10^{-1}	5.70×10^{-1}
Ground plane	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	1.02×10^{-3}
Vegetation ingestion	3.57×10^{-1}	3.63×10^{-1}	7.59×10^{-2}	3.56×10^{-1}	3.57×10^{-1}	2.46×10^{-1}	3.53×10^{-1}	3.53×10^{-1}
Meat ingestion	2.83×10^{-2}	4.78×10^{-2}	1.00×10^{-2}	2.82×10^{-2}	2.90×10^{-2}	6.43×10^{-2}	2.81×10^{-2}	2.81×10^{-2}
Milk ingestion	1.40×10^{-1}	1.39×10^{-1}	2.38×10^{-2}	1.40×10^{-1}	1.40×10^{-1}	5.41×10^{-1}	1.39×10^{-1}	1.39×10^{-1}
Inhalation	2.51×10^{-1}	2.50×10^{-1}	5.27×10^{-2}	2.60×10^{-1}	2.57×10^{-1}	2.52×10^{-1}	2.58×10^{-1}	2.50×10^{-1}
Total	8.82×10^{-1}	9.06×10^{-1}	2.69×10^{-1}	8.89×10^{-1}	8.89×10^{-1}	3.42	8.90×10^{-1}	1.34
CHILD								
Plume immersion	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.11×10^{-1}	5.70×10^{-1}
Ground plane	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	1.02×10^{-3}
Vegetation ingestion	5.62×10^{-1}	5.66×10^{-1}	1.74×10^{-1}	5.62×10^{-1}	5.65×10^{-1}	2.57	5.58×10^{-1}	5.58×10^{-1}
Meat ingestion	3.54×10^{-2}	4.71×10^{-2}	1.89×10^{-2}	3.53×10^{-2}	3.64×10^{-2}	6.23×10^{-2}	3.53×10^{-2}	3.53×10^{-2}
Milk ingestion	2.24×10^{-1}	2.24×10^{-1}	5.82×10^{-2}	2.25×10^{-1}	2.25×10^{-1}	6.21×10^{-1}	2.24×10^{-1}	2.24×10^{-1}
Inhalation	2.22×10^{-1}	2.21×10^{-1}	4.17×10^{-2}	2.28×10^{-1}	2.26×10^{-1}	2.22×10^{-1}	2.28×10^{-1}	2.21×10^{-1}
Total	1.15	1.16	3.99×10^{-1}	1.16	1.16	3.58	1.16	1.16

Table B-38. Annual dose to maximally exposed individual resulting from atmospheric releases
from current SRP operation with three reactors (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.06×10^{-1}	1.11×10^{-1}	5.70×10^{-1}
Ground plane	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	6.85×10^{-4}	1.02×10^{-3}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	3.47×10^{-1}	3.46×10^{-1}	1.13×10^{-1}	3.48×10^{-1}	3.48×10^{-1}	1.31	3.46×10^{-1}	3.46×10^{-1}
Inhalation	1.27×10^{-1}	1.27×10^{-1}	1.66×10^{-2}	1.30×10^{-1}	1.29×10^{-1}	1.28×10^{-1}	1.31×10^{-1}	1.27×10^{-1}
Total	5.81×10^{-1}	5.79×10^{-1}	2.36×10^{-1}	5.84×10^{-1}	5.83×10^{-1}	1.55	5.89×10^{-1}	1.04

Table B-39. Population dose resulting from atmospheric releases from current
SRP operation with three reactors (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	5.11	5.11	5.11	5.11	5.11	5.11	6.03	7.36×10^1
Ground plane	3.70×10^{-1}	3.70×10^{-1}	3.70×10^{-1}	3.70×10^{-1}	3.70×10^{-1}	3.70×10^{-1}	3.70×10^{-1}	5.83×10^{-1}
Vegetation ingestion	2.48×10^1	2.51×10^1	5.34	2.46×10^1	2.48×10^1	1.88×10^2	2.45×10^1	2.45×10^1
Meat ingestion	4.44	6.78	1.39	4.43	4.51	1.14×10^1	4.43	4.43
Milk ingestion	6.30	6.29	1.17	6.30	6.30	2.28×10^1	6.29	6.28
Inhalation	3.94×10^1	3.91×10^1	7.38	4.05×10^1	4.01×10^1	3.96×10^1	4.00×10^1	3.91×10^1
Total	8.04×10^1	8.28×10^1	2.08×10^1	8.14×10^1	8.12×10^1	2.68×10^2	8.16×10^1	1.49×10^2

Table B-40. Annual dose to maximally exposed individual resulting from liquid releases from current SRP operation with three reactors (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	6.14×10^{-1}	2.73×10^{-1}	1.91×10^{-1}	9.68×10^{-3}	9.92×10^{-2}	3.94×10^{-2}	2.70×10^{-2}
Drinking	0.0	3.11×10^{-1}	2.33×10^{-1}	2.39×10^{-1}	2.31×10^{-1}	2.33×10^{-1}	2.31×10^{-1}	2.40×10^{-1}
Shoreline	5.23×10^{-4}	4.42×10^{-4}	4.42×10^{-4}	4.42×10^{-4}	4.42×10^{-4}	4.42×10^{-4}	4.42×10^{-4}	4.42×10^{-4}
Swimming	0.0	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}
Boating	0.0	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}
Total	5.23×10^{-4}	9.25×10^{-1}	5.06×10^{-1}	4.30×10^{-1}	2.41×10^{-1}	3.33×10^{-1}	2.71×10^{-1}	2.67×10^{-1}
TEEN								
Fish	0.0	5.60×10^{-1}	2.71×10^{-1}	1.06×10^{-1}	7.15×10^{-3}	9.70×10^{-2}	4.20×10^{-2}	2.02×10^{-2}
Drinking	0.0	2.56×10^{-1}	1.65×10^{-1}	1.69×10^{-1}	1.63×10^{-1}	1.65×10^{-1}	1.63×10^{-1}	1.70×10^{-1}
Shoreline	1.75×10^{-3}	1.48×10^{-3}	1.48×10^{-3}	1.48×10^{-3}	1.48×10^{-3}	1.48×10^{-3}	1.48×10^{-3}	1.48×10^{-3}
Swimming	0.0	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}
Boating	0.0	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}
Total	1.75×10^{-3}	8.17×10^{-1}	4.37×10^{-1}	2.77×10^{-1}	1.71×10^{-1}	2.64×10^{-1}	2.07×10^{-1}	1.91×10^{-1}
CHILD								
Fish	0.0	6.68×10^{-1}	2.55×10^{-1}	5.14×10^{-2}	6.16×10^{-3}	8.75×10^{-2}	3.53×10^{-2}	1.18×10^{-2}
Drinking	0.0	6.47×10^{-1}	3.16×10^{-1}	3.26×10^{-1}	3.12×10^{-1}	3.17×10^{-1}	3.12×10^{-1}	3.18×10^{-1}
Shoreline	3.66×10^{-4}	3.09×10^{-4}	3.09×10^{-4}	3.09×10^{-4}	3.09×10^{-4}	3.09×10^{-4}	3.09×10^{-4}	3.09×10^{-4}
Swimming	0.0	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}	1.31×10^{-6}
Boating	0.0	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}	3.94×10^{-6}
Total	3.66×10^{-4}	1.32	5.71×10^{-1}	3.78×10^{-1}	3.18×10^{-1}	4.05×10^{-1}	3.48×10^{-1}	3.30×10^{-1}

Table B-40. Annual dose to maximally exposed individual resulting from liquid releases from current SRP operation with three reactors (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	4.68×10^{-1}	3.11×10^{-1}	3.17×10^{-1}	3.06×10^{-1}	3.12×10^{-1}	3.07×10^{-1}	3.10×10^{-1}
Total	0.0	4.68×10^{-1}	3.11×10^{-1}	3.17×10^{-1}	3.06×10^{-1}	3.12×10^{-1}	3.07×10^{-1}	3.10×10^{-1}

Table B-41. Population dose resulting from liquid releases from current SRP operation with three reactors (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	2.23×10^1	1.44×10^1	1.49×10^1	1.43×10^1	1.45×10^1	1.43×10^1	1.48×10^1
Port Wentworth	0.0	3.15×10^1	2.36×10^1	2.42×10^1	2.34×10^1	2.36×10^1	2.34×10^1	2.43×10^1
Total	0.0	5.38×10^1	3.80×10^1	3.91×10^1	3.77×10^1	3.81×10^1	3.77×10^1	3.91×10^1
Sport fish	0.0	1.95	8.48×10^{-1}	4.80×10^{-1}	2.73×10^{-2}	3.04×10^{-1}	1.22×10^{-1}	7.27×10^{-2}
Commercial fish	0.0	1.13×10^{-1}	4.93×10^{-2}	2.79×10^{-2}	1.59×10^{-3}	1.77×10^{-2}	7.13×10^{-3}	4.23×10^{-3}
Shellfish	0.0	1.56×10^{-3}	7.20×10^{-5}	1.08×10^{-4}	4.92×10^{-5}	6.02×10^{-5}	5.06×10^{-5}	2.21×10^{-4}
Shoreline	5.23×10^{-3}	0.0	0.0	4.42×10^{-3}	4.42×10^{-3}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	1.31×10^{-5}	1.31×10^{-5}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	4.60×10^{-5}	4.60×10^{-5}	0.0	0.0	0.0
Total	5.23×10^{-3}	2.07	8.97×10^{-1}	5.12×10^{-1}	3.34×10^{-2}	3.22×10^{-1}	1.29×10^{-1}	7.72×10^{-2}
Grand total	5.23×10^{-3}	5.59×10^1	3.89×10^1	3.96×10^1	3.77×10^1	3.84×10^1	3.78×10^1	3.92×10^1

Table B-42. Annual dose to maximally exposed individual resulting from atmospheric releases from the Vogtle Nuclear Power Plant with two reactors (In millirems per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
ADULT								
Plume immersion	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	5.14×10^{-3}	2.86×10^{-2}
Ground plane	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	9.97×10^{-5}
Vegetation ingestion	6.94×10^{-4}	3.40×10^{-4}	8.52×10^{-4}	1.22×10^{-3}	2.10×10^{-3}	3.96×10^{-1}	0.0	0.0
Meat ingestion	3.50×10^{-5}	1.61×10^{-5}	4.27×10^{-5}	6.11×10^{-5}	1.05×10^{-4}	2.00×10^{-2}	0.0	0.0
Milk ingestion	3.78×10^{-4}	1.80×10^{-4}	4.63×10^{-4}	6.63×10^{-4}	1.14×10^{-3}	2.16×10^{-1}	0.0	0.0
Inhalation	1.34×10^{-5}	7.24×10^{-6}	1.78×10^{-5}	2.63×10^{-5}	4.52×10^{-5}	7.59×10^{-3}	0.0	0.0
Total	6.00×10^{-3}	5.43×10^{-3}	6.26×10^{-3}	6.86×10^{-3}	8.27×10^{-3}	6.44×10^{-1}	5.22×10^{-3}	2.87×10^{-2}
TEENAGER								
Plume immersion	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	5.14×10^{-3}	2.86×10^{-2}
Ground plane	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	9.97×10^{-5}
Vegetation ingestion	6.12×10^{-4}	2.41×10^{-4}	8.18×10^{-4}	1.15×10^{-3}	1.98×10^{-3}	3.32×10^{-1}	0.0	0.0
Meat ingestion	2.67×10^{-5}	9.83×10^{-6}	3.55×10^{-5}	4.97×10^{-5}	8.55×10^{-5}	1.45×10^{-2}	0.0	0.0
Milk ingestion	6.29×10^{-4}	2.41×10^{-4}	8.39×10^{-4}	1.18×10^{-3}	2.03×10^{-3}	3.42×10^{-1}	0.0	0.0
Inhalation	1.74×10^{-5}	7.96×10^{-6}	2.50×10^{-5}	3.61×10^{-5}	6.22×10^{-5}	9.44×10^{-3}	0.0	0.0
Total	6.17×10^{-3}	5.38×10^{-3}	6.60×10^{-3}	7.30×10^{-3}	9.04×10^{-3}	7.02×10^{-1}	5.22×10^{-3}	2.87×10^{-2}
CHILD								
Plume immersion	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	5.14×10^{-3}	2.86×10^{-2}
Ground plane	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	9.97×10^{-5}
Vegetation ingestion	8.72×10^{-4}	1.48×10^{-4}	1.53×10^{-3}	1.55×10^{-3}	2.54×10^{-3}	5.06×10^{-1}	0.0	0.0
Meat ingestion	3.76×10^{-5}	5.89×10^{-6}	6.58×10^{-5}	6.62×10^{-5}	1.09×10^{-4}	2.19×10^{-2}	0.0	0.0
Milk ingestion	1.16×10^{-3}	1.91×10^{-4}	2.04×10^{-3}	2.05×10^{-3}	3.37×10^{-3}	6.75×10^{-1}	0.0	0.0
Inhalation	1.85×10^{-5}	3.88×10^{-6}	3.39×10^{-5}	3.55×10^{-5}	5.84×10^{-5}	1.07×10^{-2}	0.0	0.0
Total	6.97×10^{-3}	5.23×10^{-3}	8.55×10^{-3}	8.58×10^{-3}	1.10×10^{-2}	1.22	5.22×10^{-3}	2.87×10^{-2}

Table B-42. Annual dose to maximally exposed individual resulting from atmospheric releases from the Vogtle Nuclear Power Plant with two reactors (In millirems per year) (continued)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
INFANT								
Plume immersion	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	4.80×10^{-3}	5.14×10^{-3}	2.86×10^{-2}
Ground plane	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	8.21×10^{-5}	9.97×10^{-5}
Vegetation ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Meat ingestion	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Milk ingestion	2.20×10^{-3}	1.87×10^{-4}	4.25×10^{-3}	5.02×10^{-3}	5.86×10^{-3}	1.64	0.0	0.0
Inhalation	1.33×10^{-5}	1.50×10^{-6}	2.68×10^{-5}	3.29×10^{-5}	3.84×10^{-5}	9.81×10^{-3}	0.0	0.0
Total	7.09×10^{-3}	5.07×10^{-3}	9.16×10^{-3}	9.93×10^{-3}	1.08×10^{-2}	1.66	5.22×10^{-3}	2.87×10^{-2}

Table B-43. Population dose resulting from atmospheric releases from the Vogtle Nuclear Power Plant with two reactors (In person-rem per year)

Pathway	Total body	GI-tract	Bone	Liver	Kidney	Thyroid	Lung	Skin
Plume immersion	1.83×10^{-2}	1.83×10^{-2}	1.83×10^{-2}	1.83×10^{-2}	1.83×10^{-2}	1.83×10^{-2}	2.21×10^{-2}	2.78×10^{-1}
Ground plane	1.75×10^{-4}	1.75×10^{-4}	1.75×10^{-4}	1.75×10^{-4}	1.75×10^{-4}	1.75×10^{-4}	1.75×10^{-4}	2.13×10^{-4}
Vegetation ingestion	4.69×10^{-3}	1.50×10^{-3}	6.84×10^{-3}	8.29×10^{-3}	1.40×10^{-2}	2.69	0.0	0.0
Meat ingestion	1.02×10^{-4}	3.88×10^{-5}	1.38×10^{-4}	1.79×10^{-4}	3.04×10^{-4}	5.82×10^{-2}	0.0	0.0
Milk ingestion	7.61×10^{-4}	2.28×10^{-4}	1.14×10^{-3}	1.35×10^{-3}	2.27×10^{-3}	4.36×10^{-1}	0.0	0.0
Inhalation	1.61×10^{-4}	6.76×10^{-5}	2.36×10^{-4}	3.13×10^{-4}	5.33×10^{-4}	9.18×10^{-2}	0.0	0.0
Total	2.41×10^{-2}	2.03×10^{-2}	2.68×10^{-2}	2.86×10^{-2}	3.55×10^{-2}	3.29	2.23×10^{-2}	2.78×10^{-1}

Table B-44. Annual dose to maximally exposed individual resulting from liquid releases
from the Vogtle Nuclear Power Plant with two reactors (In millirems per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Fish	0.0	1.52	2.31	1.59	9.14×10^{-2}	7.82×10^{-1}	2.57×10^{-1}	5.02×10^{-2}
Drinking	0.0	1.14×10^{-2}	2.87×10^{-2}	2.32×10^{-2}	1.48×10^{-1}	1.83×10^{-2}	1.34×10^{-2}	1.27×10^{-2}
Shoreline	1.13×10^{-3}	9.70×10^{-4}	9.70×10^{-4}	9.70×10^{-4}	9.70×10^{-4}	9.70×10^{-4}	9.70×10^{-4}	9.70×10^{-4}
Swimming	0.0	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}
Boating	0.0	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}
Total	1.13×10^{-3}	1.54	2.34	1.62	2.40×10^{-1}	8.01×10^{-1}	2.71×10^{-1}	6.39×10^{-2}
TEEN								
Fish	0.0	1.56	2.29	8.62×10^{-1}	8.20×10^{-2}	7.76×10^{-1}	2.97×10^{-1}	3.62×10^{-2}
Drinking	0.0	1.11×10^{-2}	2.44×10^{-2}	1.43×10^{-2}	1.25×10^{-1}	1.46×10^{-2}	1.02×10^{-2}	8.96×10^{-3}
Shoreline	3.79×10^{-3}	3.25×10^{-3}	3.25×10^{-3}	3.25×10^{-3}	3.25×10^{-3}	3.25×10^{-3}	3.25×10^{-3}	3.25×10^{-3}
Swimming	0.0	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}
Boating	0.0	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}
Total	3.79×10^{-3}	1.57	2.32	8.79×10^{-1}	2.10×10^{-1}	7.94×10^{-1}	3.11×10^{-1}	4.84×10^{-2}
CHILD								
Fish	0.0	2.03	2.13	3.52×10^{-1}	8.84×10^{-2}	6.94×10^{-1}	2.47×10^{-1}	1.47×10^{-2}
Drinking	0.0	3.22×10^{-2}	4.92×10^{-2}	2.15×10^{-2}	2.96×10^{-1}	2.84×10^{-2}	1.93×10^{-2}	1.63×10^{-2}
Shoreline	7.93×10^{-4}	6.79×10^{-4}	6.79×10^{-4}	6.79×10^{-4}	6.79×10^{-4}	6.79×10^{-4}	6.79×10^{-4}	6.79×10^{-4}
Swimming	0.0	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}	3.83×10^{-6}
Boating	0.0	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}	1.15×10^{-5}
Total	7.93×10^{-4}	2.07	2.18	3.74×10^{-1}	3.85×10^{-1}	7.23×10^{-1}	2.67×10^{-1}	3.17×10^{-2}

Table B-44. Annual dose to maximally exposed individual resulting from liquid releases from the Vogtle Nuclear Power Plant with two reactors (In millirems per year) (continued)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
INFANT								
Drinking	0.0	3.36×10^{-2}	5.78×10^{-2}	1.93×10^{-2}	4.56×10^{-1}	2.88×10^{-2}	1.97×10^{-2}	1.58×10^{-2}
Total	0.0	3.36×10^{-2}	5.78×10^{-2}	1.93×10^{-2}	4.56×10^{-1}	2.88×10^{-2}	1.97×10^{-2}	1.58×10^{-2}

Table B-45. Population dose resulting from liquid releases from the Vogtle Nuclear Power Plant with two reactors (In person-rem per year)

Pathway	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
Drinking water								
Beaufort-Jasper	0.0	9.29×10^{-1}	1.91	1.29	8.48	1.16	8.49×10^{-1}	7.59×10^{-1}
Port Wentworth	0.0	1.14	2.88	2.34	1.22×10^1	1.82	1.36	1.25
Total	0.0	2.07	4.79	3.63	2.07×10^1	2.98	2.21	2.01
Spent fish	0.0	5.13	7.11	3.92	1.41×10^{-1}	2.38	8.16×10^{-1}	1.20×10^{-1}
Commercial fish	0.0	2.98×10^{-1}	4.13×10^{-1}	2.28×10^{-1}	6.36×10^{-3}	1.38×10^{-1}	4.74×10^{-2}	6.90×10^{-3}
Shellfish	0.0	9.74×10^{-5}	1.27×10^{-4}	7.34×10^{-5}	6.42×10^{-4}	1.30×10^{-4}	1.70×10^{-5}	3.95×10^{-4}
Shoreline	1.13×10^{-2}	0.0	0.0	9.70×10^{-3}	9.70×10^{-3}	0.0	0.0	0.0
Swimming	0.0	0.0	0.0	3.83×10^{-5}	3.83×10^{-5}	0.0	0.0	0.0
Boating	0.0	0.0	0.0	1.34×10^{-4}	1.34×10^{-4}	0.0	0.0	0.0
Total	1.13×10^{-2}	5.43	7.52	4.16	1.58×10^{-1}	2.52	8.63×10^{-1}	1.27×10^{-1}
Grand total	1.13×10^{-2}	7.50	1.23×10^1	7.79	2.09×10^1	5.50	3.07	2.14

Table B-46. Maximum individual doses--tenth year atmospheric releases cumulative impact (millirem)

Source of Exposure	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
L-Reactor ^a	3.5×10^{-1}	1.0×10^{-1}	2.3×10^{-1}	2.3×10^{-1}	8.3×10^{-1}	2.3×10^{-1}	2.3×10^{-1}	2.4×10^{-1}
DWPF	1.6×10^{-4}	1.9×10^{-2}	6.6×10^{-4}	4.7×10^{-3}	9.4×10^{-3}	4.2×10^{-4}	3.0×10^{-4}	1.1×10^{-3}
FMF	3.2×10^{-6}	1.0×10^{-3}	8.3×10^{-7}	6.3×10^{-5}	8.3×10^{-7}	2.4×10^{-4}	2.7×10^{-4}	7.2×10^{-5}
SRPb	1.3	2.3×10^{-1}	8.2×10^{-1}	8.1×10^{-1}	4.1	8.2×10^{-1}	8.2×10^{-1}	8.5×10^{-1}
Vogtle ^c	2.9×10^{-2}	6.3×10^{-3}	6.9×10^{-3}	6.0×10^{-3}	6.4×10^{-1}	8.3×10^{-3}	5.2×10^{-3}	5.4×10^{-3}
Total	1.7	3.6×10^{-1}	1.1	1.1	5.6	1.1	1.1	1.1
TEEN								
L-Reactor ^a	3.7×10^{-1}	1.1×10^{-1}	2.5×10^{-1}	2.5×10^{-1}	7.1×10^{-1}	2.5×10^{-1}	2.5×10^{-1}	2.5×10^{-1}
DWPF	1.7×10^{-4}	2.4×10^{-2}	8.7×10^{-4}	5.8×10^{-3}	7.2×10^{-3}	5.0×10^{-4}	4.2×10^{-4}	1.1×10^{-3}
FMF	3.2×10^{-6}	1.7×10^{-3}	8.3×10^{-7}	1.0×10^{-4}	8.3×10^{-7}	4.0×10^{-4}	4.7×10^{-4}	8.8×10^{-5}
SRPb	1.3	2.7×10^{-1}	8.9×10^{-1}	8.8×10^{-1}	3.4	8.9×10^{-1}	8.9×10^{-1}	9.1×10^{-1}
Vogtle ^c	2.9×10^{-2}	6.6×10^{-3}	7.3×10^{-3}	6.2×10^{-3}	7.0×10^{-1}	9.0×10^{-3}	5.2×10^{-3}	5.4×10^{-3}
Total	1.7	4.1×10^{-1}	1.1	1.1	4.8	1.1	1.1	1.2
CHILD								
L-Reactor ^a	4.3×10^{-1}	1.6×10^{-1}	3.1×10^{-1}	3.1×10^{-1}	7.6×10^{-1}	3.1×10^{-1}	3.1×10^{-1}	3.2×10^{-1}
DWPF	1.9×10^{-4}	3.9×10^{-2}	1.2×10^{-3}	9.6×10^{-3}	6.8×10^{-3}	5.9×10^{-4}	4.5×10^{-4}	9.2×10^{-4}
FMF	3.2×10^{-6}	4.0×10^{-3}	8.3×10^{-7}	2.4×10^{-4}	8.4×10^{-7}	6.6×10^{-4}	4.2×10^{-4}	6.9×10^{-5}
SRPb	1.2	4.0×10^{-1}	1.2	1.2	3.6	1.2	1.2	1.2
Vogtle ^c	2.9×10^{-2}	8.6×10^{-3}	8.6×10^{-3}	7.0×10^{-3}	1.2	1.1×10^{-2}	5.2×10^{-3}	5.2×10^{-3}
Total	1.7	6.1×10^{-1}	1.5	1.5	5.6	1.5	1.5	1.5

Table B-46. Maximum individual doses--tenth year atmospheric releases cumulative impact (millirem) (continued)

Source of Exposure	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	Gf-Lil
INFANT								
L-Reactor ^a	3.0×10^{-1}	1.0×10^{-1}	1.8×10^{-1}	1.7×10^{-1}	3.6×10^{-1}	1.8×10^{-1}	1.8×10^{-1}	1.7×10^{-1}
DWPF	1.5×10^{-4}	2.0×10^{-3}	6.5×10^{-4}	4.3×10^{-4}	2.7×10^{-3}	3.0×10^{-4}	2.9×10^{-4}	1.5×10^{-4}
FMF	3.2×10^{-6}	1.3×10^{-4}	8.3×10^{-7}	1.1×10^{-5}	8.3×10^{-7}	2.8×10^{-5}	3.2×10^{-4}	1.9×10^{-6}
SRP ^b	1.0	2.4×10^{-1}	5.8×10^{-1}	5.8×10^{-1}	1.6	5.8×10^{-1}	5.9×10^{-1}	5.8×10^{-1}
Vogtle ^c	2.9×10^{-2}	9.2×10^{-3}	9.9×10^{-3}	7.1×10^{-3}	1.7	1.1×10^{-2}	5.2×10^{-3}	5.1×10^{-3}
Total	1.3	3.5×10^{-1}	7.7×10^{-1}	7.6×10^{-1}	3.7	7.7×10^{-1}	7.8×10^{-1}	7.6×10^{-1}

^aIncludes support facilities.

^bCurrent SRP operation with three reactors.

^cVogtle Power Plant operation with two reactors.

Table B-47. Maximum individual doses--tenth year liquid releases cumulative impact (millirem)

Source of Exposure	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ADULT								
Co & Cs Remobilization	2.7×10^{-4}	3.4×10^{-1}	4.7×10^{-1}	3.1×10^{-1}	2.3×10^{-4}	1.6×10^{-1}	5.3×10^{-2}	9.4×10^{-3}
L-Reactor ^a	1.7×10^{-4}	3.0×10^{-1}	1.4×10^{-1}	1.4×10^{-1}	1.2×10^{-1}	1.2×10^{-1}	1.2×10^{-1}	1.4×10^{-1}
DWPF	2.6×10^{-5}	5.9×10^{-5}	7.5×10^{-3}	7.7×10^{-3}	7.7×10^{-3}	7.7×10^{-3}	7.7×10^{-3}	8.6×10^{-3}
FMF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRP ^b	5.2×10^{-4}	9.3×10^{-1}	5.1×10^{-1}	4.3×10^{-1}	2.4×10^{-1}	3.3×10^{-1}	2.7×10^{-1}	2.7×10^{-1}
Vogtle ^c	1.1×10^{-3}	1.5	2.3	1.6	2.4×10^{-1}	8.0×10^{-1}	2.7×10^{-1}	6.4×10^{-2}
Total	2.1×10^{-3}	3.1	3.4	2.5	6.1×10^{-1}	1.4	7.2×10^{-1}	4.9×10^{-1}
TEEN								
Co & Cs Remobilization	9.1×10^{-4}	3.5×10^{-1}	4.7×10^{-1}	1.7×10^{-1}	7.8×10^{-4}	1.6×10^{-1}	6.3×10^{-2}	7.5×10^{-3}
L-Reactor ^a	5.9×10^{-4}	2.6×10^{-1}	1.1×10^{-1}	9.5×10^{-2}	8.2×10^{-2}	9.1×10^{-2}	8.5×10^{-2}	1.0×10^{-1}
DWPF	8.5×10^{-5}	1.1×10^{-4}	5.5×10^{-3}	5.5×10^{-3}	5.5×10^{-3}	5.4×10^{-3}	5.5×10^{-3}	6.6×10^{-3}
FMF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRP ^b	1.8×10^{-3}	8.2×10^{-1}	4.4×10^{-1}	2.8×10^{-1}	1.7×10^{-1}	2.6×10^{-1}	2.1×10^{-1}	1.9×10^{-1}
Vogtle ^c	3.8×10^{-3}	1.6	2.3	8.8×10^{-1}	2.1×10^{-1}	7.9×10^{-1}	3.1×10^{-1}	4.8×10^{-2}
Total	7.2×10^{-3}	3.0	3.3	1.4	4.7×10^{-1}	1.3	6.7×10^{-1}	3.5×10^{-1}

Table B-47. Maximum individual doses--tenth year liquid releases cumulative impact (millirem) (continued)

Source of Exposure	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
CHILD								
Co & Cs Remobilization	1.9×10^{-4}	4.7×10^{-1}	4.5×10^{-1}	6.6×10^{-2}	1.6×10^{-4}	1.5×10^{-1}	5.3×10^{-2}	3.0×10^{-3}
L-Reactor ^a	1.2×10^{-4}	4.4×10^{-1}	1.8×10^{-1}	1.6×10^{-1}	1.5×10^{-1}	1.6×10^{-1}	1.5×10^{-1}	1.7×10^{-1}
DWPF	1.8×10^{-5}	7.1×10^{-5}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	5.3×10^{-3}	1.0×10^{-2}	1.1×10^{-2}
FMF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRP ^b	3.7×10^{-4}	1.3	5.7×10^{-1}	3.8×10^{-1}	3.2×10^{-1}	4.1×10^{-1}	3.5×10^{-1}	3.3×10^{-1}
Vogtle ^c	7.9×10^{-4}	2.1	2.2	3.7×10^{-1}	3.9×10^{-1}	7.2×10^{-1}	2.7×10^{-1}	3.2×10^{-2}
Total	1.5×10^{-3}	4.3	3.4	9.9×10^{-1}	8.7×10^{-1}	1.4	8.3×10^{-1}	5.5×10^{-1}
INFANT								
Co & Cs Remobilization	0.0	7.2×10^{-3}	8.5×10^{-3}	6.1×10^{-4}	0.0	2.3×10^{-3}	9.2×10^{-4}	3.4×10^{-5}
L-Reactor ^a	0.0	1.8×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}
DWPF	0.0	3.5×10^{-5}	9.9×10^{-3}	9.9×10^{-3}	9.9×10^{-3}	3.4×10^{-3}	9.9×10^{-3}	1.0×10^{-2}
FMF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRP ^b	0.0	4.7×10^{-1}	3.1×10^{-1}	3.2×10^{-1}	3.1×10^{-1}	3.1×10^{-1}	3.1×10^{-1}	3.1×10^{-1}
Vogtle ^c	0.0	3.4×10^{-2}	5.8×10^{-2}	1.9×10^{-2}	4.6×10^{-1}	2.9×10^{-2}	2.0×10^{-2}	1.6×10^{-2}
Total	0.0	6.9×10^{-1}	5.4×10^{-1}	5.0×10^{-1}	9.3×10^{-1}	4.9×10^{-1}	4.9×10^{-1}	4.9×10^{-1}

^aIncludes support facilities.

^bCurrent SRP operation with three reactors.

^cVogtle Power Plant operation with two reactors.

Table B-48. Population doses--tenth year cumulative impact (person-rem)

Source of Exposure	Skin	Bone	Liver	Total body	Thyroid	Kidney	Lung	GI-LLI
ATMOSPHERIC								
L-Reactor ^a	4.2×10^1	8.8	1.7×10^1	1.6×10^1	1.1×10^2	1.7×10^1	1.7×10^1	1.7×10^1
DWPF ^b	1.2×10^{-2}	1.0	5.0×10^{-2}	2.3×10^{-1}	3.1×10^{-1}	3.5×10^{-2}	3.1×10^{-2}	5.1×10^{-2}
FMF	8.1×10^{-4}	4.0×10^{-2}	2.1×10^{-4}	2.6×10^{-3}	2.1×10^{-4}	8.3×10^{-3}	1.9×10^{-2}	1.8×10^{-3}
SRP ^c	1.5×10^2	2.1×10^1	8.1×10^1	8.0×10^1	2.7×10^2	8.1×10^1	8.2×10^1	8.3×10^1
Vogtle ^d	2.8×10^{-1}	2.7×10^{-2}	2.9×10^{-2}	2.4×10^{-2}	3.3	3.6×10^{-2}	2.2×10^{-2}	2.0×10^{-2}
Total	1.9×10^2	3.1×10^1	9.8×10^1	9.6×10^1	3.8×10^2	9.8×10^1	9.9×10^1	1.0×10^2
LIQUID								
Co & Cs Remobilization	2.7×10^{-3}	1.3	1.7	8.7×10^{-1}	2.3×10^{-3}	5.6×10^{-1}	1.9×10^{-1}	4.0×10^{-2}
L-Reactor ^a	1.7×10^{-3}	2.2×10^1	1.8×10^1	1.9×10^1	1.8×10^1	1.8×10^1	1.8×10^1	2.0×10^1
DWPF ^b	2.6×10^{-4}	5.0×10^{-3}	1.2	1.2	1.2	1.1	1.2	1.4
FMF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRP ^c	5.2×10^{-1}	5.6×10^1	3.9×10^1	4.0×10^1	3.8×10^1	3.8×10^1	3.8×10^1	3.9×10^1
Vogtle ^d	1.1×10^{-2}	7.5	1.2×10^1	7.8	2.1×10^1	5.5	3.1	2.1
Total	2.1×10^{-2}	8.7×10^1	7.2×10^1	6.9×10^1	7.8×10^1	6.3×10^1	6.0×10^1	6.3×10^1
Grand Total	1.9×10^2	1.2×10^2	1.7×10^2	1.7×10^2	4.6×10^2	1.6×10^2	1.6×10^2	1.6×10^2

^aIncludes support facilities.^bCombined stage 1 & 2 operation.^cCurrent SRP operation with three reactors.^dWith two reactors.

facilities, current SRP operations with three reactors and their support facilities, and the other nuclear facilities being built in the affected region (VNGS, DWPF, and FMF).

B.5 ENVIRONMENTAL DOSE COMMITMENT CONCEPT

Man can receive doses externally from radioactive materials outside the body or internally from the intake of radioactive material by inhalation or ingestion. Radionuclides that enter the body are distributed to various organs and are removed by normal biological processes and radioactive decay. The rate at which each radionuclide is removed from the body depends on its chemical, physical, and radiological properties. Historically, dose calculations have included an accounting of doses resulting from the fraction of radionuclides retained in the body for 50 years following the year of intake. This 50-year "integrating period" is included in the dose commitment factors used in these dose calculations.

Similarly, radioactive material released in any year remains in the environment for varying lengths of time, depending on many environmental factors and on the decay rate of each radionuclide. The environmental dose commitment (EDC) concept is employed to account for this residual activity.

The EDC concept has been developed by the U.S. Environmental Protection Agency (EPA, 1974). EPA has defined the environmental dose commitment as "... the sum of all doses to individuals over the entire time period the material persists in the environment in a state available for interaction with humans." The EPA report describes how this concept is implemented and presents some sample calculations. These calculations integrate doses for 100 years following radionuclide release rather than "the entire time period." This 100-year integrating period is distinct from the 50-year integrating period discussed above because it deals with the accumulation of doses from residual radioactivity in the environment rather than in the body.

The 100-year integrating period was used in this analysis; in other words, all population dose calculations will include an accounting of population doses caused by environmental radioactivity levels for 100 years following each year's release. The 100-year period provides results that are meaningful by accounting for impacts over a period of time about equal to the maximum lifetime of an individual; thus, it provides a measure of risk to an individual. Longer integrating periods or an infinite time integral would require extremely speculative predictions about man's environment for thousands of years into the future.

For all EDC calculations, no attempt was made to predict changes in environmental characteristics. Population size and distribution were based on the latest estimates. Historic meteorology was assumed to continue into the future. Food production and consumption patterns were assumed to be static.

B.6 RADIATION-INDUCED HEALTH EFFECTS

Radiation can affect human health by causing cancer, genetic disorders, and other health problems. The Committee on the Biological Effects of Ionizing Radiation (BEIR) of the National Academy of Sciences has published a detailed review of available data on radiation-induced health effects (BEIR, 1980). This report (BEIR III) uses a variety of methods and data to quantify the health impacts of low levels of radiation. Its estimates of health risk associated with radiation exposure have been used to quantify the possible radiation-induced health effects that might be caused by L-Reactor operation; these potential health effects are discussed in Sections 4.1.2.6, 5.1.2.5, 5.1.2.7, and 5.2.7.

The BEIR III report identifies three categories of radiation-induced human health effects: (1) cancer, (2) genetic disorders, and (3) somatic effects other than cancer. The committee believes cancer induction is the most important effect of low-dose radiation. In this context, "low dose" refers to doses as high as a few rads per person per year. Natural background radiation ranges from 0.1 to 0.2 rad per person per year. Genetic effects of low-level radiation have been well documented and are addressed in detail in the BEIR III report. Somatic effects other than cancer include such effects as cataract induction and the impairment of fertility. The BEIR III report concludes that low-dose exposure of human populations does not increase the risk of somatic effects other than cancer and developmental changes in unborn children. The report also indicates that developmental changes in unborn children are probably not caused by radiation at or below natural background levels. For these reasons, only cancer and genetic disorders are considered in this analysis.

Cancer data from the Japanese survivors of atomic bombs are used in most of the analyses in the BEIR III report. Individual dose rates of these individuals were very high compared to the dose rates associated with L-Reactor operation. A major question addressed by the BEIR III report is how to extrapolate the cancer risks observed at the relatively high dose rates down to the lower dose rates caused by most nuclear facilities. The BEIR III report adopted a parametric family of functions to accomplish this extrapolation. The linear model represents an upper limit or maximum risk; the linear-quadratic model, an intermediate or probable risk; and the quadratic model, a low limit or minimum risk. These functions have been suggested by the report for low linear energy transfer (LET) radiation. This type of radiation includes gamma and x-radiation and electrons (beta particles). High-LET radiation includes alpha particles, encountered in the decay of radionuclides in the natural uranium decay chain. The BEIR III report states that, for high-LET radiation "... the linear hypothesis is less likely to lead to overestimates of risk and may, in fact, lead to underestimates." The linear model would, therefore, represent the best estimate for probable risk from this type of radiation.

One characteristic of radiation-induced cancer is that it takes a long time to develop, a period referred to as the "latent period." Leukemia has a characteristically short latent period (less than 25 years), while other cancers can have latent periods as long as the life span of an individual. Because only about 30 years of cancer data have been collected on the survivors of the atomic bombs, the data do not account for all the cancers that might develop because of the bomb's radiation. Two projection models have been developed to account for these future cancer deaths: (1) the absolute-risk projection model assumes that

the cancer rate (risk per year) observed since the atomic bomb blasts will continue throughout the lifespans of those exposed; (2) the relative-risk model assumes the excess radiation-induced risk is proportional to the natural incidence of cancer with age. The relative-risk model results in cancer-risk estimates greater than those predicted by the absolute model. However, the BEIR III report states that the absolute model is generally more applicable to most forms of cancer. The absolute model has been used in calculating the minimum risk, the relative model has been used for the maximum risk, and the arithmetic average of the two for the probable-risk estimates.

Health effects estimators for low-LET and high-LET radiation were derived for use in estimating health effects based on an evaluation of the data presented in the BEIR III report. The resulting health effects estimators used in this document are summarized in Table B-49. They total 120 fatalities per million person-rem for low-LET radiation and 285 fatalities per million person-rem for high-LET radiation. The health effects estimates for genetic effects used in this document is 257 genetic effects per million person-rem of whole-body gamma radiation.

Table B-49. Health effects estimators used in the evaluation of radiation health effects

TC	Organ/cancer	Cancer fatalities per 10 ⁶ person-rem	
		Low-LET radiation ^{a,b}	High-LET radiation ^{a,b}
	Leukemia and bone cancer	20.0	45.0
	Lung	34.0	66.0
	Liver	7.9	16.0
	Kidney	4.0	7.8
	Gastrointestinal tract	6.4	13.0
	Thyroid ^c	0.0	0.0
	Other	<u>48.0</u>	<u>137.0</u>
	Total	120.3	284.8

^aLET = linear energy transfer.

TC | ^bThe arithmetic average of the absolute and relative model values have been used for both low- and high-LET radiation. In addition, the linear-quadratic model has been assumed for low-LET radiation and the linear model has been assumed for high-LET radiation (refer to Section B.6).

^cAlthough thyroid cancer can be induced, it is rarely fatal (BEIR, 1980).

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APPENDIX C

ECOLOGY

The Savannah River Plant (SRP) occupies a 780-square-kilometer site on the upper coastal plain of South Carolina (Figure C-1). At the time of government acquisition, approximately one-third of the site was forested and the rest was cropland. During the past 32 years, natural succession, forestry management practices, and the construction and operation of nuclear reactors and their support facilities have contributed to the current ecological complexity and diversity.

In 1972, the Savannah River Plant was designated a National Environmental Research Park. It contains perhaps one of the most intensively studied environments in this country. Wiener and Smith (1981) list more than 700 scientific publications resulting principally from research efforts by three institutions on the SRP site: the Savannah River Laboratory, the Savannah River Ecology Laboratory, and the U.S. Forest Service. Other research efforts include: (1) surveys of the aquatic ecology of the Savannah River since 1951 by the Academy of Natural Sciences of Philadelphia, (2) temperature and flow monitoring of the river by the United States Geological Survey (USGS) since 1959, (3) remote sensing of the plant using aerial imagery, and (4) various ecological studies by state government and by industry. In addition, research has been performed by visiting scientists from other universities and laboratories in the United States.

This appendix is based on these sources, and also on recent ecological studies conducted by the Savannah River Ecology Laboratory (SREL) and Environmental and Chemical Services, Inc. (ECS). These studies include research by Smith et al. (1981, 1982a,b, 1983), Du Pont (1982, 1983), and ECS (1982, 1983a,b,c). This appendix emphasizes Steel Creek and the Savannah River swamp (Figure C-1), and the "important" biota that reside there, as these areas will be impacted by L-Reactor for both the reference case (direct discharge) and the preferred cooling-water alternative (see Appendix L for more detail). The important biota are defined as species that are (1) commercially or recreationally valuable, (2) endangered or threatened, (3) important to the well-being of the species included in categories 1 and 2, or (4) critical to the structure and function of the ecosystem. | TC

C.1 SOILS

Soils are an important component of the environment because they influence the occurrence and distribution of the vegetation, wildlife, and potential land use by man. The distribution of soils of the Steel Creek watershed is shown in Figure C-2. The portion of the watershed depicted here covers approximately 20,000 acres, and includes 24 different soil types (Table C-1). The most widely distributed soils of the Steel Creek watershed include Blanton sand (14 percent), Wagram loamy sand (13 percent), Troup sand (12 percent), Orangeburg loamy sand (8 percent), Rembert sandy loam (8 percent), Fuquay loamy sand (7 percent), and Wehadkee loam (7 percent). Streambed soils of Steel Creek consist primarily

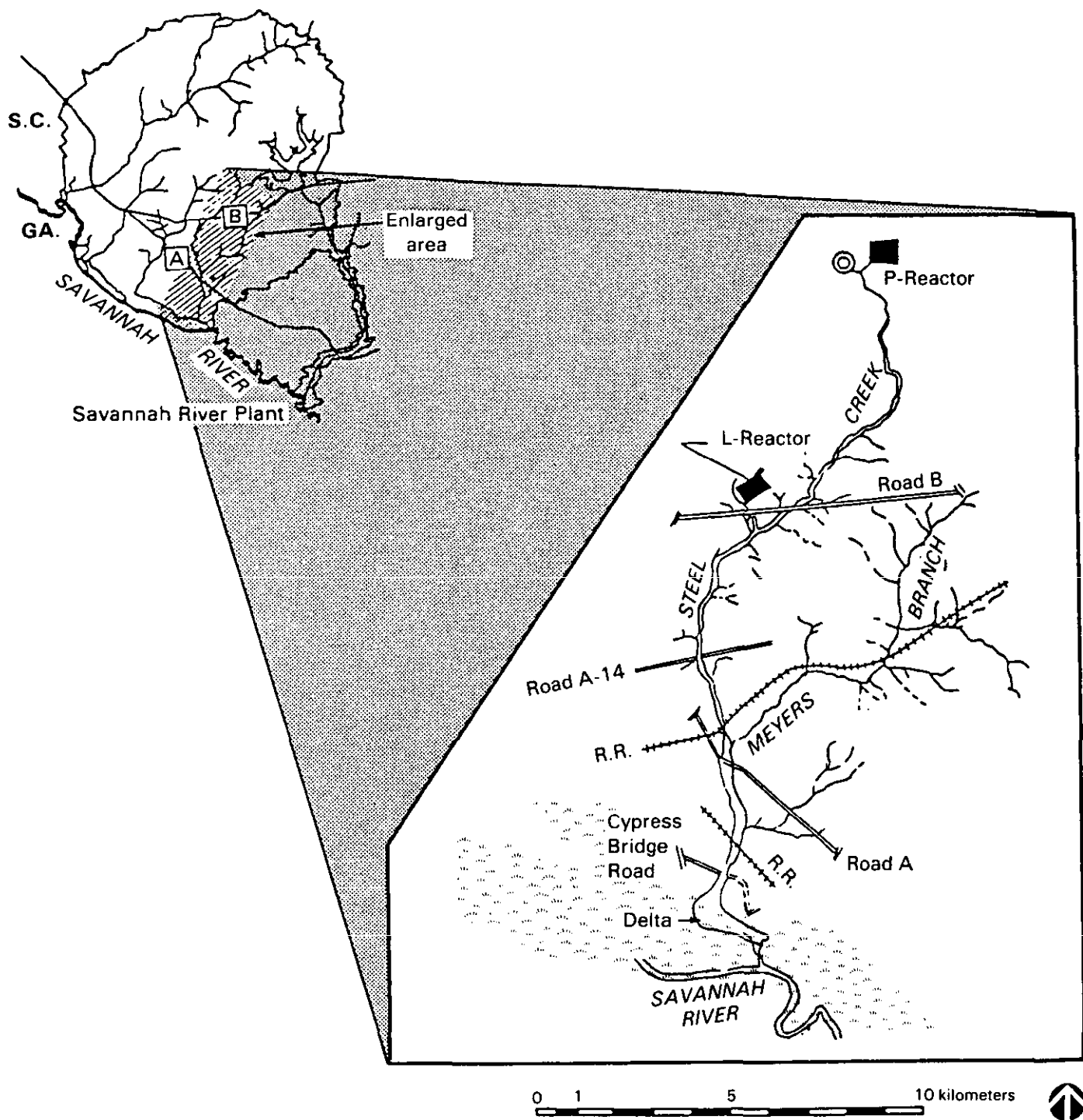


Figure C-1. Site location of L-Reactor and its immediate environment on the Savannah River Plant.

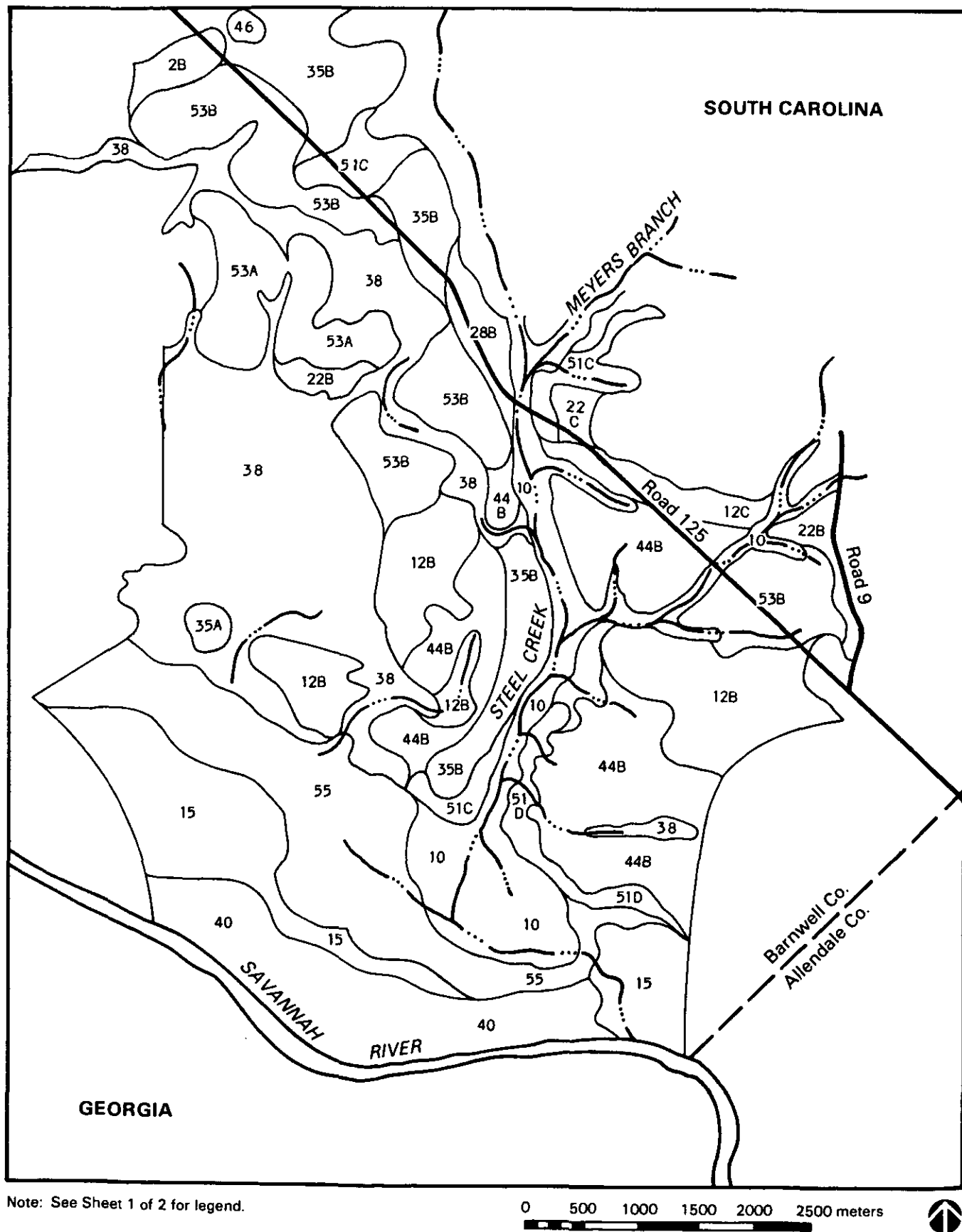


Figure C-2. General soils map of the Steel Creek watershed (Sheet 2 of 2).

Table C-1. Occurrence, distribution, and selected characteristics of the soils of the Steel Creek watershed

Soil name	Map symbol	Texture (A horizon)	Drainage class	Hectares	Acres	Percent
Ailey	2	Loamy sand	Well drained	104	258	1.3
Arents and Udorthents	5	Sandy loam or sandy clay loam	Poorly drained	63	155	0.8
Bibb	10	Sandy loam	Poorly drained	560	1,383	6.9
Blanton	12	Sand	Well drained	1098	2,714	13.5
Chewacla	15	Sandy loam	Poorly drained	288	712	3.5
Dothan	18	Loamy sand	Well drained	4	11	0.1
Fuquay	22	Loamy sand	Well drained	604	1,492	7.4
Johnston	25	Mucky loam	Poorly drained	100	247	1.2
Lakeland	27	Sand	Well drained	79	195	1.0
Lucy	28	Loamy sand	Well drained	67	166	0.8
Norfolk	30	Loamy sand	Well drained	116	287	1.4
Ocilla	33	Sand	Poorly drained	4	11	0.1
Orangeburg	35	Loamy sand	Well drained	678	1,676	8.4
Rembert	38	Sandy loam	Poorly drained	681	1,682	8.4
Shellbluff	40	Silty loam	Well drained	253	626	3.1
Troup	44	Sand	Well drained	994	2,456	12.2
Udorthents and Arents	45	Loam	Poorly drained	74	184	0.9
Udorthents-Urban	46	Sandy clay loam	Well drained	221	545	2.7
Urban	47	Variable	Variable	7	17	0.1
Vaucluse	50	Loamy sand	Well drained	74	184	0.9
Vaucluse-Ailey complex	51	Loamy sand	Well drained	79	195	1.0
Wagram	53	Loamy sand	Well drained	1034	2,554	12.7
Wehadkee	55	Loam	Poorly drained	581	1,435	7.2
Troup-Lucy complex	60	Loamy sandy	Well drained	353	872	4.3
Total				8116	20,057	99.9

of Bibb sandy loam; these soils were scoured and eroded during previous reactor operations. The dominant texture of the surficial horizons is loamy sand and sandy loam. Slopes typically range less than 6 percent, and most soils are well drained.

C.2 VEGETATION

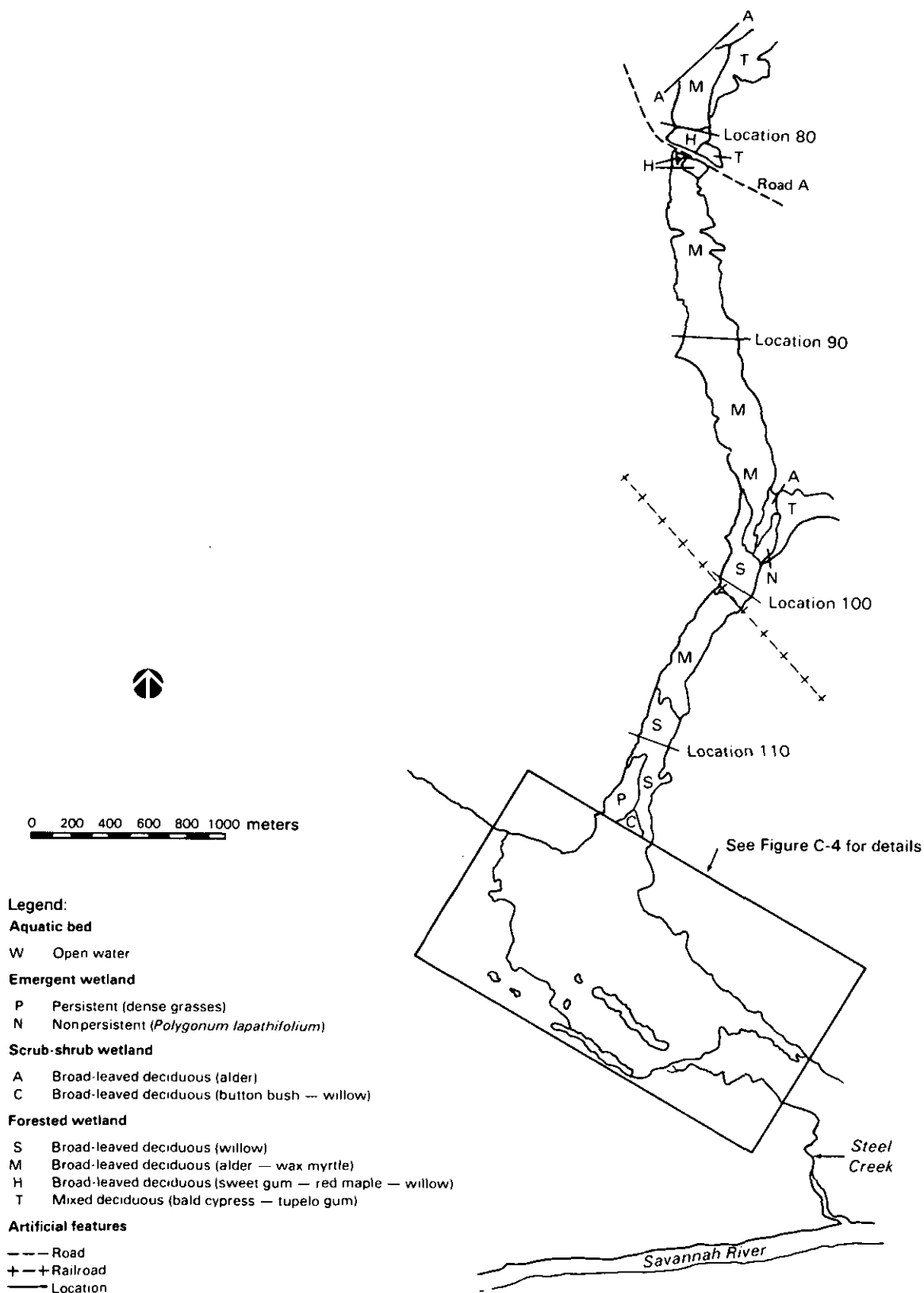
The phytogeography of Georgia and South Carolina includes two principal forest types. Associated with the Piedmont is the oak-hickory-pine forest whereas the southern mixed forest overlies the coastal plain (Kuchler, 1964). Dominant canopy species of the oak-hickory-pine forest include hickory, short-leaf and loblolly pine, white oak, and post oak. Beech, sweetgum, magnolia, slash and loblolly pine, white oak, and laurel oak characterize the canopy of the southern mixed forest. The southern floodplain forest, which adjoins major rivers such as the Savannah, typically consists of tupelo, numerous species of oak, and bald cypress.

The Savannah River Plant (SRP) is near the line that divides the oak-hickory-pine forest and the southern mixed forest. Consequently, species representative of each occur. In addition, SRP vegetation has been influenced strongly by farming, fire, edaphic features, and topography. There is no virgin forest in the region (Braun, 1950). Except for the nuclear production areas and their support facilities, many previously disturbed areas have been reclaimed by natural plant succession or have been planted with pine by the U.S. Forest Service.

The vegetation that will be most affected by the proposed action includes: (1) the plant communities of the Steel Creek corridor from the reactor outfall to the delta, and (2) the Steel Creek delta, which is contiguous with the Savannah River swamp (Figure C-3). The structure and species composition of these communities reflects not only the heterogeneity of the physical environment, but also the influence of previous reactor operations.

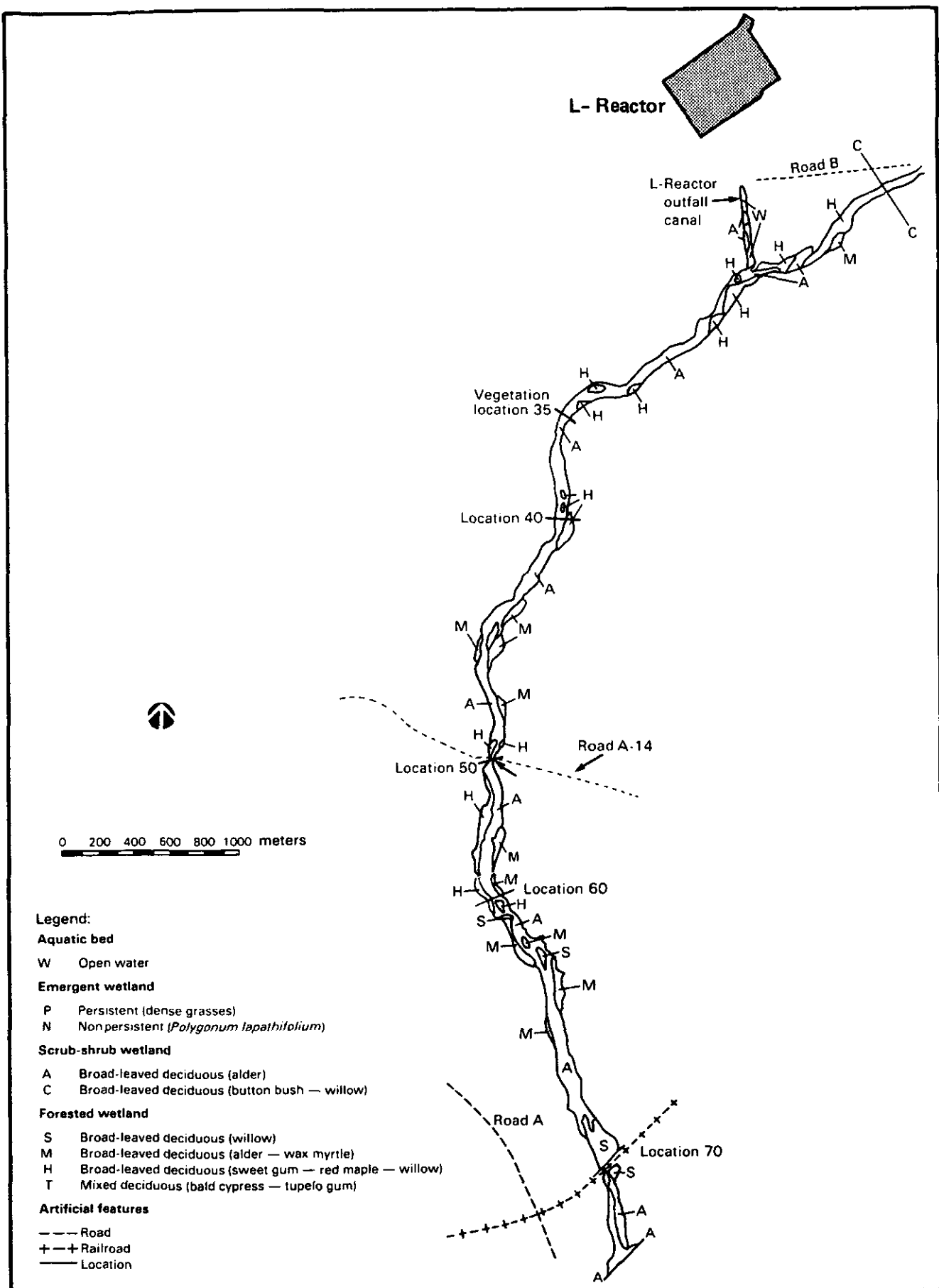
During earlier L-Reactor operations, the thermal effluent eliminated vegetation in the Steel Creek channel, floodplain, and swamp. A delta developed rapidly at the entrance of the creek to the swamp from the sediments transported down the creek. A tree-kill zone, covering about 300 acres, developed in the swamp.

These impacts were caused by the elevation of stream temperatures and marked increases in the stream flow. The discharge of thermal reactor effluents into Steel Creek before 1968 essentially eradicated the emergent and semiemergent flora, as well as portions of the swamp forest, leaving stumps and standing dead cypress and tupelo. Since 1968, when the reactor was shut down, the Steel Creek corridor and portions of the swamp have been overgrown by successional woody and herbaceous vegetation (Smith et al., 1981, 1982a).



Source: Smith et al. (1981).

Figure C-3. Steel Creek corridor vegetation map and sampling locations. (Sheet 1 of 2)



Source: Smith et al. (1981).

Figure C-3. Steel Creek corridor vegetation map and sampling locations. (Sheet 2 of 2)

C.2.1 Steel Creek corridor

The vegetation of the Steel Creek corridor, which is classified as palustrine wetland (Cowardin et al., 1979), varies markedly between P-Reactor and the delta. More than 85 species of plants representing 50 families were listed in this area in the summer of 1981 (Smith et al., 1981). Tables C-2 and C-3 list the structural attributes of the flora, including estimates of the species' basal area and biomass. Figure C-3 shows the distribution of the principal plant communities, including sampling locations. The following detailed list describes the characteristic vegetation in the various communities:

1. Aquatic bed

W - Open Water. The outfall canal of L-Reactor contained open water bordered by persistent herbaceous species and occasional shrubs.

2. Emergent wetland

P - Persistent. This community was dominated by dense grasses and forbs with scattered low shrubs.

N - Nonpersistent. A single small area existed just north of location 100. It was dominated by Polygonum spp. with a border of persistent herbs including cattail, burreed (Sparganium americanum), Canada rush (Juncus canadensis), and sugarcane beardgrass (Erianthus giganteus).

3. Scrub-shrub wetland

Broad-leaved deciduous

C - Cephalanthus occidentalis - Salix spp. This community consisted of a dense shrub canopy dominated by buttonbush and willow near the mouth of Steel Creek.

A - Alnus serrulata. Alder (Alnus serrulata) was the dominant species on Steel Creek, although wax myrtle (Myrica cerifera) and willow (Salix spp.) were locally abundant. Beneath these shrubs, blackberry (Rubus spp.) was abundant over a diverse herbaceous flora of Hypericum spp., false nettle, goldenrod (Solidago canadensis), wapato, jewelweed (Impatiens capensis), Polygonum spp., Aneilema keisak, cut-grass, knotgrass, and Ludwigia virgata. These herbs also covered open areas along stream channels within this vegetation type and were the dominant ground cover in some of the other woody mapping units described below.

This community generally bordered the stream channels and, for most of the length of Steel Creek, extended nearly across the width of the floodplain. Narrow strips of young hardwood trees of other species bordering the upland were included in the boundary of this unit. The height of the shrubs was greater near the mouth of Steel Creek than near the L-Reactor outfall. The density varied from nearly impenetrable thickets between

Table C-2. Basal area of woody species sampled
from the Steel Creek corridor^a
(In square meters per hectare)

Species	Sampling location ^b			
	10	35	50	100
Trees				
<u>Acer rubrum</u>	0.08			0.72
<u>Amelanchier</u> sp.				0.03
<u>Baccharis halimifolia</u>	0.52			0.20
<u>Cornus florida</u>				0.05
<u>Liquidambar styraciflua</u>	0.14	0.06		0.23
<u>Liriodendron tulipifera</u>				8.68
<u>Myrica cerifera</u>				0.59
<u>Pinus taeda</u>				0.25
<u>Platanus occidentalis</u>	0.31			
<u>Salix</u> spp.	1.93	0.70		
Total	2.98	0.76	0	10.75
Shrubs				
<u>Acer rubrum</u>	0.08		1.35	
<u>Alnus serrulata</u>	9.37	3.27	11.87	1.20
<u>Campsis radicans</u>				0.03
<u>Liquidambar styraciflua</u>				0.53
<u>Myrica cerifera</u>	2.79			
<u>Platanus occidentalis</u>	0.41			0.20
<u>Quercus</u> spp.	1.23			
<u>Salix</u> spp.		0.20	0.01	
Total	13.88	3.47	13.23	1.96
Grand Total	16.86	4.23	13.23	12.71

^aAdapted from Smith et al. (1981).

^bSampling locations are shown in Figure C-3.

Table C-3. Occurrence and biomass of herbaceous flora sampled from the Steel Creek corridor^a
(In grams per square meter)

Species	Sampling location ^b				Average
	10	35	50	100	
<u>Acer rubrum</u>	0.52	0.52			0.26
<u>Aneilema keisak</u>				90.60	22.65
<u>Boehmeria cylindrica</u>	0.32	8.36	180.80		47.37
<u>Campsis radicans</u>	0.08				0.02
<u>Cicuta maculata</u>				19.20	4.80
<u>Cuscuta spp.</u>		7.56	2.12		2.42
<u>Decumaria barbara</u>	0.64				0.16
<u>Galium obtusum</u>		0.48			0.12
<u>Galium tinctorum</u>			0.24		0.06
<u>Gelsemium sempervirens</u>	2.68				0.67
<u>Gnaphalium sp.</u>	0.08				0.02
<u>Hydrocotyle sp.</u>			0.32		0.08
<u>Hypericum mutilum</u>		9.36	6.84		4.05
<u>Hypericum walteri</u>		0.08		12.92	3.25
<u>Impatiens capensis</u>		4.64	4.64	4.20	3.37
<u>Juncus effusus</u>		5.36	8.84		3.55
<u>Leersia spp.</u>	0.72			1.76	0.62
<u>Lespedeza sp.</u>		0.20	11.88		3.02
<u>Lonicera japonica</u>	0.48			1.16	0.41
<u>Ludwigia virgata</u>		8.88	3.36		3.06
<u>Lycopus rubellus</u>		10.72			2.68
<u>Mikania scandens</u>		2.36	3.48	4.20	2.51
<u>Myrica cerifera</u>				0.36	0.09
<u>Onoclea sensibilis</u>	2.64			18.68	5.33
<u>Panicum spp.</u>	0.24	1.26	5.36		1.72
<u>Polygonum hydropiperoides</u>		25.56			6.39
<u>Polygonum sagittum</u>		4.08	0.20		1.07
<u>Rubus sp.</u>		37.04	172.68	74.44	71.04
<u>Salix spp.</u>				1.20	0.30
<u>Scirpus cyperinus</u>			25.64		6.41
<u>Scutellaria laterifolia</u>			0.60		0.15
<u>Solidago sp.</u>		1.92	3.92		1.46
Miscellaneous	0.72	0.56	0.52		0.45
Total	9.12	128.94	431.44	228.72	199.56

^aAdapted from Smith et al. (1981).

^bSampling locations are shown in Figure C-3.

locations 60 and 70 and locations 20 and 40 to sparser concentrations between locations 40 and 60.

4. Forested wetland

Broad-leaved deciduous

- S - Salix spp. Willows exceeding 5 meters in height were dominant near the mouth of Steel Creek and in a few locations near bridges and power lines farther upstream. Occasional hardwood species (e.g., sweetgum, red maple) also occurred in the canopy. Beneath the willow was a shrub layer of alder, wax myrtle, and blackberry with sparse herbaceous cover, which included some of the plants of the alder-dominated shrubland.
- M - Myrica cerifera - Alnus serrulata. Wax myrtle and alder (as high as 7 meters) were codominant, and grew in dense stands on most of the floodplain between transects 70 and 100. Willow was also abundant. This shrub canopy was broken by occasional hardwood trees (sycamore, sweet gum, red maple) on some of the more stable sandbars. Beneath the alder-wax myrtle canopy was dense blackberry and a sparse covering of the herbs listed in the alder-dominated scrub-shrub wetland description. These herbs were also dominant in old streambeds that lack abundant woody vegetation.
- H - Liquidambar styraciflua - Acer rubrum - Salix spp. Species of trees that are typical of the upland areas adjacent to Steel Creek had also become established on some of the more stable sandbars, at stream obstructions such as bridges and dikes, and along the Steel Creek upland border, especially upstream from L-Reactor. The most frequent canopy species included tulip tree (Liriodendron tulipifera), sycamore, red maple, and sweetgum. Saplings of these trees, wax myrtle, alder, blackberry, and groundsel tree (Baccharis halimifolia) were abundant in the understory. Although nearly half of the substrate surface was covered by leaf litter, many herbs and vines occur. Chief among the herbs were sensitive fern, false nettle, Hypericum spp., sericea (Lespedeza cuneata), and goldenrod. The most frequent vines included peppervine (Ampelopsis arborea) and honeysuckle (Lonicera japonica).

Mixed deciduous

- T - Taxodium distichum - Nyssa sylvatica var. biflora. This vegetation type was dominated by cypress (Taxodium distichum) intermixed with some water gum (Nyssa sylvatica var. biflora) on parts of the Steel Creek corridor. In the Savannah River swamp, cypress and water tupelo (N. aquatica) dominated the canopy.

North of location 30, Steel Creek is narrow, bordered by alder and confined between steep banks that rise nearly 5 meters above the floodplain. Sandbars covered by persistent emergent herbs and forested wetland dominated by sweetgum, red maple, and willow occurred where the stream meanders.

Between locations 30 and 70, the stream border was dominated by dense alder 3 to 5 meters tall with a patchy ground cover. More upland areas were dominated by alder intermixed with wax myrtle and willow. Open areas dominated by blackberry and herbaceous flora occurred in partially filled remnant stream channels. This vegetation was dense where total sunlight was available, but formed a sparse ground cover beneath shrubs. Hardwood saplings bordered the upland.

From locations 70 to 110, the elevation of the Steel Creek floodplains was approximately 0.6 meter lower than the upland hardwoods. A dense growth of the wax myrtle-alder-dominated scrub-shrub wetland extended from within 10 meters of the upland to approximately 3 meters from the active stream channel. Willow was locally dominant in some areas of this corridor segment. The channel was bordered by a zone of low persistent herbs dominated by wapato, cut-grass, and Aneilema keisak. Remnant-braided stream channels and open areas elevated slightly above the stream beds were dominated by species characteristic of the alder-dominated scrub-shrub wetland. These species also formed the ground cover beneath the shrub thickets.

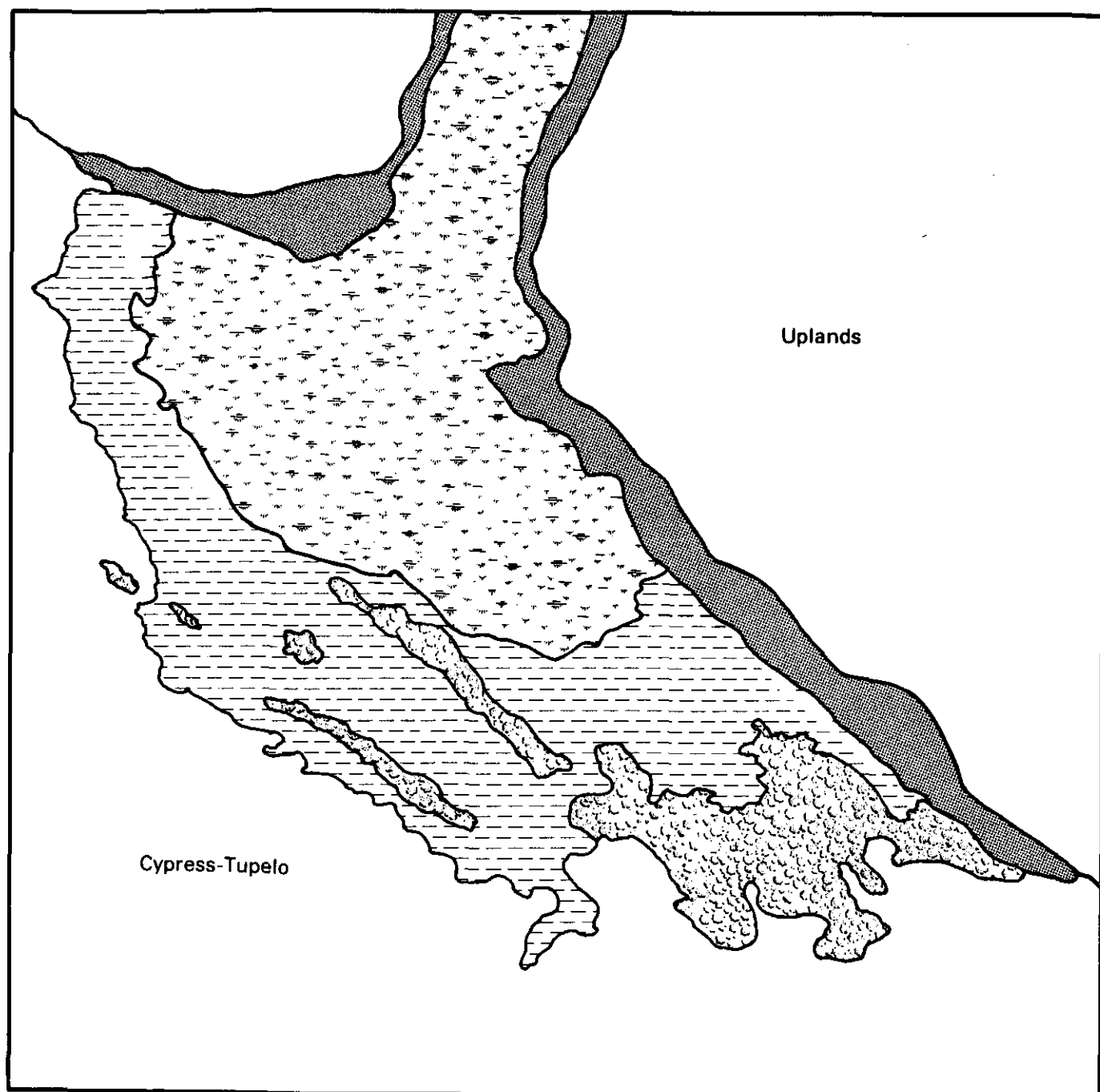
The vegetative composition of the lower segment of Steel Creek (from location 110 to the delta) was similar to that found in the delta. The persistent emergent wetland species described for the delta dominated the western portion of the creek. Willow and buttonbush increased in density toward the eastern bank.

C.2.2 Steel Creek delta

The Steel Creek delta, which is adjoined by the Savannah River swamp near the mouth of Steel Creek, contained several vegetative associations, four of which are differentiated by the degree of previous reactor impact and the hydrologic regime (Figure C-4). Impacted zones that have experienced structural reductions of the canopy include deepwater habitats and deltaic fan. Bottomland and upland hardwoods comprised the nonimpacted zones. Since the shutdown of L-Reactor in 1968, patterns of vegetative recovery have varied according to the hydrologic regime. The distribution of the principal plant communities was associated almost exclusively with these various zones.

The deltaic fan zone, which was formed by the deposition of sediments at the mouth of Steel Creek, consisted of a raised substrate composed primarily of organic and alluvial deposits over sand. It measured approximately 500 by 1200 meters, was stabilized by vegetation, and was traversed by many old streambeds less than 1 meter deep. The more successional advanced vegetation stages that occurred here included (1) broad-leaved deciduous forest (Salix spp.), (2) scrub-shrub wetland (Cephalanthus occidentalis - Salix spp.), and (3) persistent emergent wetland (Leersia spp.).

The impacted deepwater zone extended as an arc on the periphery of the deltaic fan. Most of the trees in this zone were destroyed during reactor operation. The zone was characterized by scattered cypress, an abundance of stumps bearing shrubs, and submergent and nonpersistent aquatic herbs. The main channel of Steel Creek flowed through this zone after passing through the delta. The rooted vascular aquatic bed, nonpersistent emergent wetland, mixed forest/



Legend:

0 200 400 600 meters



Impacted



Deepwater (deeply flooded)



Deltaic fan (shallow flooded)

Nonimpacted



Bottomland hardwoods (seasonally flooded)



Upland (intermittently flooded)

Source: Smith et al. (1981).

Figure C-4. Vegetative zones of Steel Creek delta resulting from L-Reactor operation (1952-1968) and associated hydrologic regimes.

scrub-shrub wetland, and mixed scrub-shrub/rooted vascular wetland associations were well developed.

The nonimpacted deepwater zone contained mixed deciduous forest that was typical of the swamp before reactor operations began on the Savannah River Plant. The underlying substrate near the impacted zone was composed of fine particulate material less than 0.5 meter deep (Ruby et al., 1981).

The bottomland hardwood zone is generally flooded in the spring, but not during the growing season. Two types of broad-leaved deciduous forest were found exclusively in this zone: (1) areas dominated by laurel oak (Quercus laurifolia) are inundated only during the river flood stage; (2) those intermixed with overcup oak (Q. lyrata), water hickory (Carya aquatica), and water tupelo (Nyssa aquatica), might retain standing water until early in the growing season.

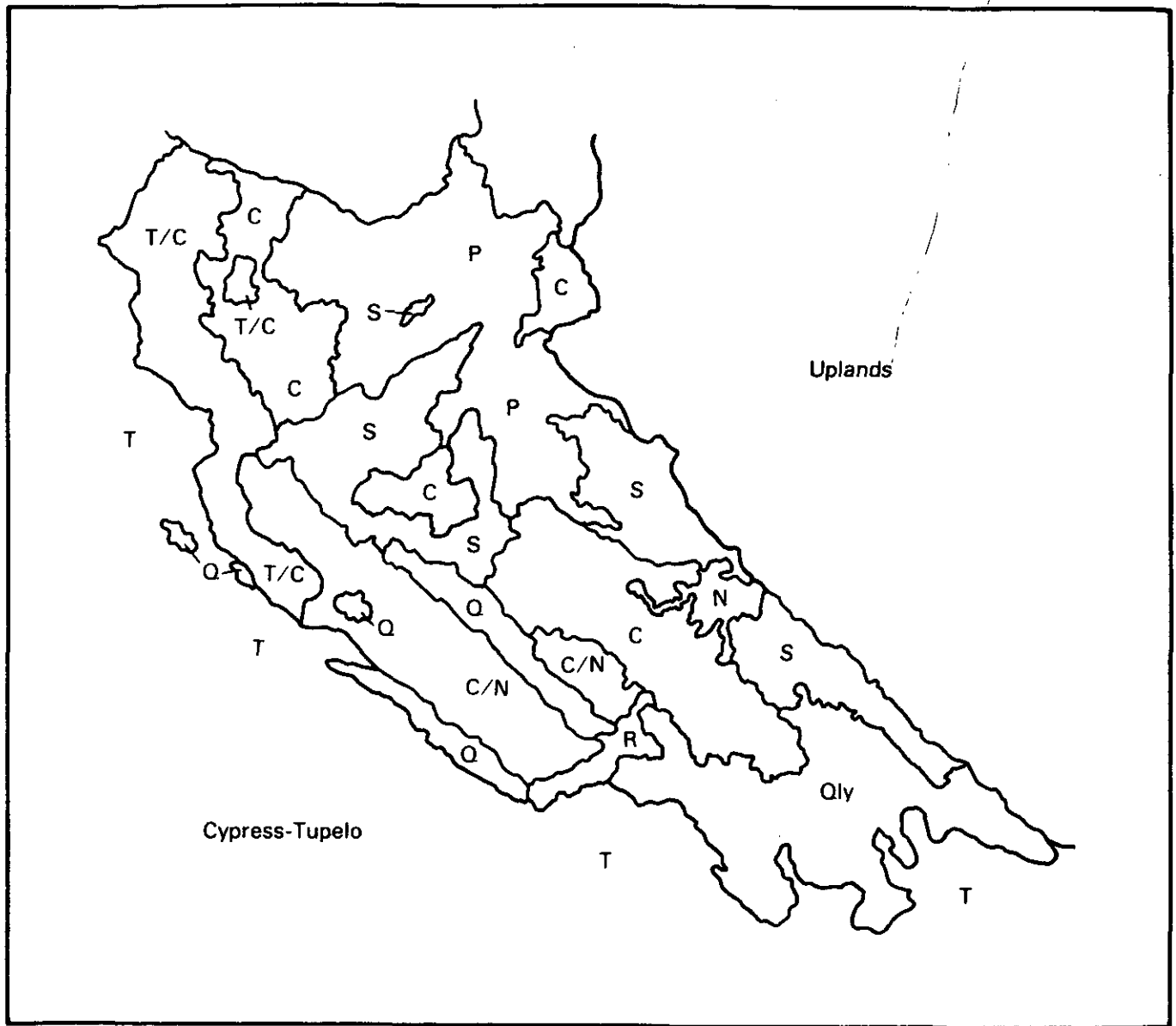
Figure C-5 shows the distribution of the principal plant communities of the Steel Creek delta, determined from 1978 aerial photography and field studies conducted during the summer of 1981; the classification and mapping terminology follow Cowardin et al. (1979), with minor modifications (Smith et al., 1981). All categories are termed palustrine, which includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, or emergent mosses or lichens.

Approximately one-fourth of the delta area was covered by shrub communities that were dominated by buttonbush and willow (Table C-4). Five habitat types (P, S, Qly, C/N, and T/C) were similar in area of coverage, and three minor habitat types also occurred. Forested areas dominated by cypress and water tupelo bordered the delta; their coverage was not measured. More than 123 species of plants representing 66 families were listed during the 1981 field studies. Tables C-5 and C-6 list basal areas of trees and shrubs and biomass for herbaceous flora. The following list describes the plant associations of the Steel Creek delta:

1. Aquatic bed

Rooted vascular

R - Myriophyllum brasiliense. In the impacted deepwater zone where the main flow of Steel Creek courses northeasterly, the open water, which is approximately 2 meters deep, predominates beneath scattered live bald cypress trees that are remnants from the pre-SRP swamp. Scattered stumps of dead trees supported shrubs (e.g., buttonbush (Cephalanthus occidentalis), Virginia willow (Itea virginica)), young trees (e.g., water ash (Fraxinus caroliniana), water elm (Planera aquatica)), and herbs (e.g., false nettle (Boehmeria cylindrica), marsh St.-Johnswort (Hypericum walteri)). Patches of duckweed (Lemna perpusilla) inhabit mats of submerged vascular plants such as hornwort (Ceratophyllum demersum) and parrotfeather (Myriophyllum brasiliense), which root on subsurface logs and on tree and stump bases. Where the water flow is slow, Polygonum spp. formed dense colonies.



Legend:

0 200 400 600 meters



Aquatic bed

R Rooted vascular (parrot-feather)

Emergent wetland

P Persistent (cut grass)

N Nonpersistent (hydrolea)

Scrub-shrub wetland

C Broad-leaved deciduous (buttonbush — willow)

C/N Mixed scrub-shrub/nonpersistent emergent (buttonbush — polygonum)

Forested wetland

S Broad-leaved deciduous (willow)

Q Broad-leaved deciduous (laurel oak)

Qly Broad-leaved deciduous (overcup oak — water hickory — tupelo gum)

T Mixed deciduous (bald cypress — tupelo gum)

T/C Mixed forested/scrub-shrub (bald cypress — buttonbush)

Source: Smith et al. (1981).

Figure C-5. Vegetation map of Steel Creek delta based on 1978 aerial photographs and 1981 field studies.

Table C-4. Areal coverage and relative abundance of principal plant associations of Steel Creek delta^a

Mapping unit	Symbol	Dominant flora	Area		Percent
			Hectares	Acres	
Scrub-shrub wetland	C	<u>Cephalanthus</u> - <u>Salix</u> (buttonbush-willow)	29	72	23.1
Emergent wetland (persistent)	P	<u>Leersia</u> (cut-grass)	22	55	17.7
Broad-leaved deciduous	S	<u>Salix</u> spp.	21	51	16.6
Broad-leaved deciduous forest	Qly	<u>Quercus lyrata</u> - <u>Carya</u> - <u>Nyssa</u> (overcup oak - water hickory - water tupelo)	17	42	13.5
Mixed scrub-shrub	C/N	<u>Cephalanthus/Polygonum</u> (buttonbush/Polygonum)	16	39	12.4
Mixed forested/scrub- shrub	T/C	<u>Taxodium/Cephalanthus</u> (bald cypress/buttonbush)	13	31	10.1
Broad-leaved deciduous forest	Q	<u>Quercus laurifolia</u> (laurel oak)	5	13	4.3
Emergent wetland	N	<u>Hydrolea</u> (hydrolea)	2	4	1.4
Rooted vascular	R	<u>Myriophyllum</u> (parrot- feather)	1	3	1.0
Total			126	310	100.1

^aAdapted from Smith et al. (1981).

Table C-5. Basal area of trees and shrubs of Steel Creek delta^a
(In square meters per acre)

Species	Mapping unit ^b						Qly	Q
	P	C/N	C	S	T/C	T		
Trees								
<u>Carya aquatica</u>								3.20
<u>Celtis leavigata</u>							0.36	1.54
<u>Cephalanthus occidentalis</u>			0.04		0.25			0.06
<u>Crataegus</u> spp.							0.02	
<u>Forestiera accuminata</u>							0.06	
<u>Fraxinus americana</u>				0.10			1.42	
<u>Fraxinus caroliniana</u>		0.17			0.93	0.51		1.42
<u>Ilex opaca</u>								0.01
<u>Liquidambar styraciflua</u>		0.02					0.56	
<u>Nyssa aquatica</u>					0.69	11.37	4.09	
<u>Planera aquatica</u>		0.10			0.06	.27	0.51	0.03
<u>Platanus occidentalis</u>							1.36	
<u>Quercus laurifolia</u>		0.06			0.09			0.17
<u>Quercus lyrata</u>								2.41
<u>Quercus nigra</u>								4.66
<u>Salix</u> spp.	0.01		0.50	3.35				
<u>Taxodium distichum</u>		1.17			7.65	12.97	5.03	
<u>Ulmus</u> spp.						0.05		0.01
Total	0.01	1.52	0.54	3.45	9.67	25.17	13.41	13.51

Table C-5. Basal area of trees and shrubs of Steel Creek delta^a (continued)
(In square meters per acre)

Species	Mapping unit ^b							
	P	C/N	C	S	T/C	T	Qly	Q
Shrubs								
<u>Amelopsis arborea</u>			0.03					
<u>Cephalanthus occidentalis</u>			0.15		0.07			
<u>Fraxinus caroliniana</u>					0.09			
<u>Ilex decidua</u>								0.02
<u>Salix</u> spp.			0.23					
Total	0.0	0.0	0.41	0.0	0.16	0.0	0.0	0.02
Total basal area	0.01	1.52	0.95	3.45	9.83	25.17	13.41	13.53
Number of quadrants	3	3	8	3	5	3	3	3

^aAdapted from Smith et al. (1981).

^bSymbols of the palustrine system--aquatic bed: P = persistent (Myriophyllum brasiliense); scrub-shrub wetland: C/N = mixed scrub-shrub/nonpersistent emergent (Cephalanthus occidentalis/Polygonum spp.); C = broad-leaved deciduous (Cephalanthus occidentalis - Salix nigra) nonpersistent; forested wetland: S = broad-leaved deciduous (Salix spp.), T/C = mixed forested/scrub-shrub (Taxodium distichum/Cephalanthus occidentalis), T = mixed deciduous (Taxodium distichum-Nyssa aquatica), Qly = broad-leaved deciduous (Quercus lyrata - Carya aquatica - Nyssa aquatica), Q = broad-leaved deciduous (Quercus laurifolia).

Table C-6. Occurrence and biomass of herbaceous species in the
Steel Creek delta, summer 1981^a
(In grams per square meter)

Species	Mapping unit ^b										
	R	N	P	C/N	C	S	T/C	T	Qly	Q	Mean
<u>Ampelopsis arborea</u>					3.82	0.14			0.04	0.28	0.84
<u>Aneilema keisak</u>		16.96	30.56	11.16	42.20	65.36					19.14
<u>Apios americana</u>						7.40					0.33
<u>Aster sp.</u>		0.76				8.32					0.58
<u>Berchemia scandens</u>									2.52		0.25
<u>Bidens frondosa</u>						1.44	8.00				0.89
<u>Boehmeria cylindrica</u>			20.76		4.08	26.96	0.04	12.60	3.60		5.04
<u>Campsis radicans</u>									0.08		0.01
<u>Cephalanthus occidentalis</u>					0.04						0.01
<u>Ceratophyllum demersum</u>				11.28							1.13
<u>Cicuta maculata</u>		1.00			0.24		1.04				0.24
<u>Cyperus haspan</u>			3.18								0.32
<u>Echinodorus cordifolius</u>				6.72		0.92					0.73
<u>Galium tinctorium</u>			0.07	0.24	0.16	0.08					0.06
<u>Gelsemium sempervirens</u>									0.08		0.04
<u>Hydrocotyle sp.</u>					0.09						0.03
<u>Hydrolea quadrivalvis</u>		60.68	3.59	29.88	7.51	2.28	0.32				9.58
<u>Hypericum mutilum</u>			38.11		0.48	0.04					0.08
<u>Hypericum walteri</u>		2.56	22.28	19.36	18.96	7.12	6.20				8.56
<u>Ilex opaca</u>									0.08		0.01
<u>Itea virginica</u>									0.36		0.04
<u>Leersia spp.</u>		9.96	374.43	62.88	52.92	0.09	13.56				60.52
<u>Ludwigia palustris</u>		56.92	0.27	26.72	13.20	0.01					13.57
<u>Lycopus rubellus</u>						0.97					0.06
<u>Lycopus virginicus</u>					1.52		0.80				0.23
<u>Mikania scandens</u>				0.60	1.17	3.68		3.20			0.75
<u>Myriophyllum brasiliense</u>		31.68		38.80		4.28					7.48
<u>Onoclea sensibilis</u>					0.02	27.12			2.44		2.14

Table C-6. Occurrence and biomass of herbaceous species in the Steel Creek delta, summer 1981^a (continued)
(In grams per square meter)

Species	Mapping unit ^b										
	R	N	P	C/N	C	S	T/C	T	Qly	Q	Mean
<u>Panicum agrostoides</u>					55.36	50.23					10.39
<u>Polygonum hydropiperoides</u>	356.08	271.72	52.02	105.56	29.24	9.68	34.60				86.21
<u>Polygonum spp.</u>				171.16	29.60						21.05
<u>Rhynchospora corniculata</u>				5.32	15.76	91.60					7.85
<u>Rubus sp.</u>										0.56	0.06
<u>Sagittaria latifolia</u>		144.84	50.97	37.92	42.30	16.80					28.65
<u>Salix spp.</u>						0.22					0.01
<u>Scirpus cyperinus</u>			176.76								
<u>Saururus cernus</u>						4.16			0.08		
<u>Scutellaria laterifolia</u>						1.08					0.06
<u>Smilax bona-nox</u>										3.68	0.37
<u>Smilax walteri</u>									0.32	16.48	1.68
Miscellaneous		0.88	4.99	0.12	1.24	5.33		8.28	0.08	0.16	1.96
Total	356.08	597.96	777.99	527.72	388.82	335.31	64.56	24.08	9.68	21.44	318.25

^aAdapted from Smith et al. (1981, 1982a). (See Figure C-4)

^bThe following are symbols of the palustrine system. Aquatic bed: R-rooted vascular (Myriophyllum brasiliense); emergent wetland: N = nonpersistent (Hydrolea quadrivalus), P = persistent (Leersia spp.); scrub-shrub wetland: C/N = mixed scrub-shrub/nonpersistent emergent (Cephalanthus occidentalis/Polygonum spp.); C = broad-leaved deciduous (Cephalanthus occidentalis - Salix spp.); forested wetland: S = broad-leaved deciduous (Salix nigra), T/C = mixed forested/scrub-shrub (Taxodium distichum/Cephalanthus occidentalis), T = mixed deciduous (Taxodium distichum - Nyssa aquatica), Qly = broad-leaved deciduous (Quercus lyrata - Carya aquatica - Nyssa aquatica), Q = broad-leaved deciduous (Quercus laurifolia).

2. Emergent wetland

Persistent

- P - Leersia spp. Persistent emergent monocots dominated a large area (17.7 percent of the delta) of the deltaic fan. Except during extreme drought, the water level during the growing season was 10 to 50 centimeters deep (excluding old stream channels that are as deep as 1 meter).

Although the dominant herbaceous species varied with water depth and location on the deltaic fan, scattered shrubs (buttonbush and willow) were usually present. Cut-grass (Leersia spp.) was dominant, with redtop panicgrass (Panicum agrostoides) forming an abundant ground cover except under dense woody vegetation and in the deeper stream channels.

These grasses were usually overtopped by knotgrass (Scirpus cyperinus), that was approximately 2.5 meters tall. There were also several nearly monotypic stands of cattail (Typha latifolia). The many old stream channels that crossed the deltaic fan were dominated by the herbaceous species characteristic of the nonpersistent emergent wetland.

Nonpersistent

- N - Hydrolea quadrivalvis. In this classification, emergent vascular plants that die back to the ground and leave a winter aspect of open water are considered to be nonpersistent. This characteristic was verified by a comparison of multispectral scanner images taken in March with autumn photographs; the comparison showed open-water areas with small patches of dead vegetation in the early spring and herbaceous dominance in the fall. Patches of open water as deep as 1 meter with slight, if any, flow were common here. The substrate was a deep, fine particulate mud. With the exception of the old stream channels, this vegetation type occurred only in the impacted deepwater zone.

This community contained relatively monospecific, as well as mixed, colonies of hydrolea (Hydrolea quadrivalvis), Aneilema keisak, waterpepper (Polygonum hydropiperoides), water purslane (Ludwigia palustris), and wapato (Sagittaria latifolia). These characteristic, nonpersistent species were also common in old stream beds throughout the deltaic fan in the persistent emergent and scrub-shrub wetland types.

The many standing dead trees and stumps bear such characteristic stump community vegetation as buttonbush, water ash, water elm, false nettle, and marsh St.-Johnswort.

3. Scrub-shrub wetland

Broad-leaved deciduous

- C - Cephalanthus occidentalis - Salix spp. Most of the deltaic fan was dominated by shrub and low trees. This community was heterogeneous and exhibited considerable variation in water regimes across the entire delta. It occurred in both of the impacted deltaic deepwater zones.

In the deltaic fan, where the water was less than 50 centimeters deep, buttonbush or willow dominated the uppermost layer. Buttonbush dominated the canopy in some areas and formed the understory at sites dominated by willow. Knotgrass joined the woody species in the upper stratum whereas cut-grass covered most of the ground. Redtop panicgrass, beggarticks (Bidens frondosa), false nettle, and marsh St.-Johnswort were common in many places. Climbing hemp (Mikania scandens) and peppervine (Ampelopsis arborea) were frequently found vines in the shrubland. The scrub-shrub wetland also had open areas of persistent emergent wetland and old stream channels dominated by herbs.

The scrub-shrub wetland intergraded with the persistent emergent wetland where the shrubs were sparse, and with the broad-leaved deciduous forest vegetation where willows were more than 5 meters tall and dominant.

The scrub-shrub wetland areas located in the impacted deepwater zone differed from those in the deltaic fan zone in water regime, substrate, and ground cover. The summer water depth was approximately 0.5 to 1 meter and overlaid a substrate of decomposing vegetation and fine inorganic sediment that was about 0.5 meter deep. Buttonbush was dominant above the ground-cover species described for the nonpersistent emergent wetland.

4. Mixed scrub-shrub/nonpersistent emergent wetland

- C/N - Cephalanthus occidentalis - Polygonum spp. In the impacted deepwater zone, shrubs and young trees (buttonbush, Virginia willow, water elm, water ash) were restricted to the many stumps remaining from the original forest. Scattered live bald cypress (up to 20 meters tall) were present. The stump bases had the characteristic stump-community herbs (false nettle and marsh St.-Johnswort) and several vines including poison ivy (Rhus radicans), peppervine, and wisteria (Wisteria frutescens).

Water depths here ranged from 0.5 to 2.0 meters during the typical growing season. Some of the main flow of Steel Creek coursed swiftly through this area. Lateral to this flow, the water moved sluggishly, allowing the establishment of rooted vascular plants. More than 50 percent of the surface was dominated by Polygonum spp., erect, deeply rooted, emergent annuals that die back in the winter. Nonpersistent emergent wetland species (e.g., waterpepper and Aneilema keisak) were common; submerged

aquatics, such as hornwort and parrotfeather, were abundant. In places, this herbaceous cover at the edges of the stump communities extended as a dense mat beneath the scrub-shrub canopy.

5. Forested wetland

Broad-leaved deciduous

S - Salix spp. Willow that is up to 5 meters tall with an understory of buttonbush dominated the more elevated portions of the deltaic fan. The ground was dry or flooded by less than 15 centimeters of water. The herbaceous vegetation was relatively sparse due to the dense canopy. Small patches of herbs included reedtop panicgrass, waterpepper, false nettle, marsh St.-Johnswort, and sensitive fern (Onoclea sensibilis). The vines--climbing hemp and peppervine--were also common. Some small areas contained species that are typical of the persistent emergent wetland on the most shallow sites and of the nonpersistent emergent wetland in the old stream channels. Although drier and of a different species composition than the pre-SRP swamp, this was the most successional advanced vegetation type on the deltaic fan.

Qly - Quercus lyrata - Carya aquatica - Nyssa aquatica. Adjacent to and slightly higher in substrate elevation than the cypress-tupelo swamp was an area of broad-leaved deciduous trees. Although dry during most of the growing season, this area was subject to seasonal flooding of longer duration than areas on the deltaic fan. Several of the more common species in this vegetation type leaf out late in the season and can withstand flooding that lasts as late as July (Whitlow and Harris, 1979). Water marks on the trees indicated that the water was approximately 1.5 meters above the substrate at flood stage. The substrate consisted of a thin (approximately 2 centimeters) humus layer over an apparent clay-loam soil.

No single species clearly dominated this community. Some of the more consistently common species of the canopy and understory were water hickory, sycamore (Platanus occidentalis), red maple (Acer rubrum), white ash (Fraxinus americana), sweetgum (Liquidambar styraciflua), and bald cypress. Although apparently not being replaced, overcup oak and water tupelo were abundant canopy components.

The shrub layer included a sparse growth of possum haw (Ilex decidua), swamp privet (Forestiera acuminata), and hawthorn (Crataegus sp.). Rattan vine (Berchemia scandens) and bristly greenbrier (Smilax hispida) were the most common vines.

The duration and magnitude of seasonal flooding prevents persistent herbaceous ground cover. This vegetative layer was sparse except for occasional dense patches in low areas. Herbs found in widely scattered spots included dayflower (Commelina virginica), false nettle, and ladies tresses (Spiranthes sp.).

Q - Quercus laurifolia. This community occurred only on islands in the swamp that were slightly higher in elevation than the surrounding swamp and, therefore, were inundated for shorter periods. The canopy (more than 20 meters high) contained laurel oak, overcup oak, swamp chestnut oak (Q. michauxii), red maple, and water hickory. In addition, the subcanopy contained sweetgum, American elm (Ulmus americana), hackberry (Celtis laevigata), and ironwood (Carpinus caroliniana). Shrubs, including palmetto (Sabal minor), possum haw, and hawthorn, were widely scattered. Dense vines such as rattan vine, coral greenbrier (Smilax walteri), catbrier (Smilax rotundifolia), muscadine (Vitis rotundifolia), summer grape (Vitis aestivalis), pepper-vine, and poison ivy occurred in some areas. The ground was covered by leaf litter with widely scattered herbaceous plants including marsh fleabane (Pluchea rosea) and several grasses and sedges.

Mixed deciduous

T - Taxodium distichum - Nyssa aquatica. The cypress-tupelo swamp typical of pre-SRP conditions extended beyond the impacted deep-water zone to the Savannah River. Water as deep as 2 meters flowed slowly over a shallow substrate (less than 0.5 meter deep) composed of organic and fine particulate material. During the growing season, flooding is controlled by the regulation of reservoir levels upstream on the Savannah River and by the flow from Four Mile Creek and Pen Branch.

The canopy, which has more than 80-percent closure, was dominated by 20- to 30-meter-tall water tupelo and bald cypress; both can occur either as fairly monospecific stands or as mixtures of the two. Tree bases provided the primary substrate for a sparse growth of shrubs and herbs, as described above for the stump communities of the scrub-shrub/nonpersistent emergent wetland. Occasional patches of submergent and emergent plants, as described in the description of the rooted vascular aquatic bed, were found in association with submerged tree bases or debris.

T/C - Mixed forested/scrub-shrub wetland

Taxodium distichum - Cephalanthus occidentalis. This mapping unit occupied part of the impacted deepwater zone to the west of the deltaic fan. A patchy canopy of bald cypress (more than 20 meters tall) covered about 50 percent of the zone. The understory was a mixture of buttonbush, water ash, and water elm. Cut-grass dominated the ground cover; marsh St.-Johnswort and beggarticks were abundant. Where the cypress canopy was sparse, open areas were dominated by species of the nonpersistent emergent wetland intermixed with many stumps bearing woody growth.

The water depth varied from 50 to 80 centimeters (except in channels) over a deep (more than 50 centimeters) substrate of organic and fine inorganic sediment.

Smith et al. (1982b) presents a revised vegetative map of the Steel Creek delta based on more recent (1981) aerial photography. The principal difference between this map and Figure C-5 is that buttonbush and willow shrub communities have expanded into areas previously occupied by emergent grasses and other herbaceous species. Additionally, community classification was modified slightly due to a different ordination analysis. These changes are subtle and are not duplicated herein.

C.3 WILDLIFE

The abundance and diversity of wildlife that inhabits the Savannah River Plant reflect the interspersed and heterogeneity of the habitats occurring there. Emphasis was given to "important" species as defined previously, especially those fauna that inhabit Steel Creek and the Savannah River swamp, which are potentially affected by the direct discharge (reference case) and the preferred cooling-water alternative (see Appendix L).

C.3.1 Amphibians and reptiles

Because of its temperate climate and numerous aquatic habitats, the SRP site contains a diversified and abundant herpetofauna. Species having zoogeographic ranges that include the Savannah River Plant include 17 salamanders, 26 frogs and toads, 10 turtles, 1 crocodilian, 9 lizards, and 31 snakes (Conant, 1975). Many additional species have ranges that are peripheral to the site, and could also occur here. Gibbons and Patterson (1978) provide an overview of the herpetofauna of the entire Savannah River Plant, including comments on relative abundance and peripheral species accounts.

Based on field studies in 1981 and 1982, more than 1560 individuals representing 65 species were collected or observed in the Steel Creek area (Smith et al., 1981, 1982b). Ranked in order of decreasing relative abundance, frogs and toads, turtles, and salamanders comprised more than 85 percent of the species enumerated. Five habitat types were examined during the surveys: (1) the stream channel below and above the delta, (2) the delta, (3) islands, (4) floodplain, and (5) the swamp forest. Of these habitats, twice as many species were collected on the floodplain than in the other habitats; this was due in part to a greater diversity of terrestrial and aquatic microhabitats present there, and also because the floodplain is the characteristic habitat type of Steel Creek.

The most frequently captured terrestrial salamander was the slimy salamander (Plethodon glutinosus). Additionally, three species of Ambystoma were found at Steel Creek, of which the marbled salamander (A. opacum) was the most frequently captured species. The mole salamander (A. talpoideum) and the spotted salamander (A. maculatum) were uncommon. The tiger salamander (A. tigrinum), which is a winter breeder, is expected to inhabit Steel Creek but none were collected. Three species, the two-toed amphiuma (Amphiuma means), the greater siren (Siren lacertina), and the lesser siren (Siren intermedia) were the only species to be collected that are entirely aquatic throughout their life cycle.

Of the 26 species of frogs and toads that could inhabit Steel Creek, 14 were confirmed during the 1981 and 1982 surveys. Additional species will undoubtedly be obtained from future surveys planned for the breeding season. Based on their frequency of capture, the southern toad (Bufo terrestris) was the most abundant of the terrestrial species and the southern leopard frog (Rana utricularia) ranked first in relative abundance for the aquatic species.

More than half of the species of snakes documented on the Savannah River Plant also inhabit Steel Creek (Gibbons and Patterson, 1978). Based on relative abundance values, the poisonous eastern cottonmouth (Agkistrodon piscivorus) was the most common species. Watersnakes (genus Nerodia) were also abundant in aquatic habitats. Other venomous reptiles observed near Steel Creek were the canebrake rattlesnake (Crotalus horridus) and the southern copperhead (Agkistrodon contortrix).

Nine species of lizard were collected at Steel Creek. The six-lined race-runner (Cnemidophorus sexlineatus), broad-headed skink (Eumeces laticeps), five-lined skink (Eumeces fasciatus), and anole (Anolis carolinensis) ranked as the most abundant species. The glass lizards (Ophisaurus attenuatus and O. ventralis) were encountered less frequently, due perhaps to habitat restrictions.

Of the nine species of turtles documented on the Savannah River Plant, all but the spiny softshell (Trionyx spiniferus) were collected in the Steel Creek area. Turtles were found in all aquatic areas, but most abundantly in the delta and floodplain. Turtles inhabiting the swamp forest were either the more terrestrial species (e.g., box turtles) or were nesting females of aquatic species. Pseudemys scripta, a turtle ubiquitous in southeastern aquatic areas, was the most common; more than 200 individuals were captured, marked, and released during the summer. Several river cooters (P. concinna) were captured in the delta and in the stream channel between the delta and the Savannah River. This riparian species has never been reported from lentic habitats on the Savannah River Plant and is not expected to be common in the delta or in upstream areas. The relative abundance of eastern mud turtles (Kinosternon subrubrum) and musk turtles (Sternotherus odoratus), when compared with other species, was similar to that observed in other aquatic areas on the site. The striped mud turtle (Kinosternon bauri) has been collected in the Steel Creek system. Populations of these species probably occur throughout the Steel Creek ecosystem.

Alligator

The American alligator, an inhabitant of wetland ecosystems in the Southeast, was threatened with extinction in the 1950s and 1960s. It is listed as endangered by the Federal Government (USDOI, 1983), and threatened by the State of South Carolina. The SRP is near the northern limit of the alligator's range; in this region, winter temperatures probably restrict its distribution.

Earlier studies of the fauna of the SRP site (Freeman, 1955; Jenkins and Provost, 1964) indicate that the alligator has always been a resident of the area. Its abundance probably increased following closure of the area to the public. This isolation afforded protection from hunting for several years before such protection was provided legally.

Murphy (1981) reported sightings of alligators in the Savannah River swamp and in the major SRP streams. Alligator breeding habitat with documented nests

exists along the backwater lakes and in the swamp associated with Beaver Dam Creek, which enters the swamp several kilometers upstream from Steel Creek.

Although much of Steel Creek and the Savannah River swamp do not contain vast areas of optimum alligator habitat, patches of quality habitat are present. There are beaver ponds and Carolina bays near the river swamp or creek floodplain margins, open-water oxbow lakes, and open-canopied, marshy areas typical of productive alligator habitat described by Joanen (1969), Joanen and McNease (1970), and Smith et al. (1981, 1982a).

Studies of the American alligator in the Steel Creek ecosystem were begun in 1981 and have included censuses by foot, boat, and air, capture and release, and radiotelemetry (Smith et al., 1981, 1982a,b). These investigations have confirmed that alligators utilize the Steel Creek ecosystem from the L-Reactor outfall to the Steel Creek delta and swamps, including other areas near Steel Creek such as Carolina bays, backwater lagoons, and beaver ponds. The population of alligators in the Steel Creek ecosystem was estimated to range between 23 and 35 individuals (Smith et al., 1982b). Sex ratios and size data suggest a higher reproductive potential in Steel Creek than is known for Par Pond, where nearly 80 percent of the adults are males (Murphy, 1977).

Studies of the wintering behavior and movements of alligators in the Steel Creek ecosystem were initiated in 1981 (Smith et al., 1982a). Generally, it was found that alligators on the SRP site do not utilize over-wintering dens, but remain active whenever winter temperatures are suitable. Alligators were able to survive with a body temperature as low as 3.3°C, the coldest ever recorded for a free-ranging alligator. Based on studies using three individuals, alligators move between the lagoons near S.C. Highway 125, and utilize the swamp forest below the Steel Creek delta (Smith et al., 1982b). A single alligator nest was located at the edge of the Steel Creek delta, but hatching was unsuccessful. No additional nests have been subsequently found.

AB-4 | These studies were based on the direct discharge alternative. After DOE selected the 1000-acre lake as the preferred cooling water alternative, new studies were conducted and a new biological assessment was transmitted to FWS (Sires, 1984a). Temperatures in 50% of the lake and in Steel Creek below the embankment would be less than 32.2°C, and the critical thermal maximum temperature for alligators is 38°C. DOE is awaiting a decision on its conclusion that operation of L-Reactor under the preferred alternative would not jeopardize the continued existence of the species.

C.3.2 Avifauna

The avifauna of the Steel Creek ecosystem are among the most mobile of the vertebrates. Some species, termed resident, inhabit SRP environs year round. Others, termed migrants, use the area enroute to their breeding and wintering grounds. Several species either winter or breed in the area. Habitat affinities of birds range from cavity-nesters such as wood ducks to red-winged blackbirds, which typically nest among emergent cattails. These species-specific attributes, the isolation of the SRP site from the public, and its proximity to the Atlantic Flyway, all contribute to an abundant and diversified avifauna.

The SRP avifauna have been studied by several investigators. Norris (1963) surveyed the Savannah River Plant but presented little information about Steel Creek. Fendley (1978) initiated a study of the wood duck in the Steel Creek drainage system in 1973 that continues to date. Angerman (1979, 1980) listed 59 species on the Savannah River Plant during Christmas bird counts, but did not include specific observations along Steel Creek.

Birds of the Steel Creek ecosystem were investigated in summer 1981 at eight locations using a combination of strip censuses, mist nets, and aerial surveys. A total of 1062 birds representing 59 species was tabulated during the survey (Smith et al., 1981). These data reflect only summer populations, and winter surveys would undoubtedly augment this listing. Avifauna that potentially winter on the Savannah River Plant are listed by Smith et al. (1981).

The avifauna listed along Steel Creek in the summer of 1981 also probably breed there. Active nests of the Bachman's sparrow, parula warbler, and red-headed woodpecker were observed, as were juveniles of 22 other species. The white-eyed vireo was the most abundant species based on all census techniques, followed closely by the Carolina wren. The frequency of observation or capture of the other species was relatively similar, and no single species dominated the census results.

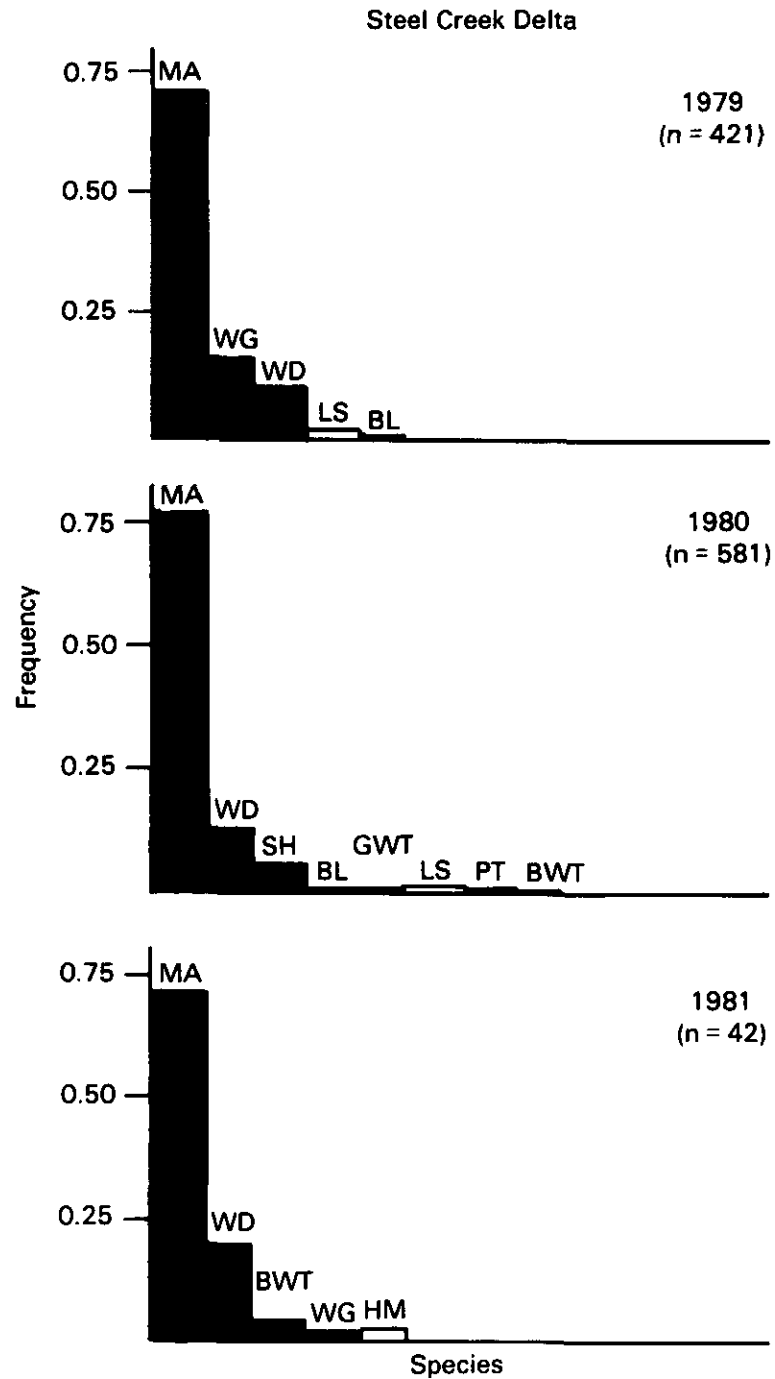
Waterfowl

Waterfowl are among the most important members of the Steel Creek avifauna. Because of the interspersed habitats and isolation from the public, the Steel Creek delta and Savannah River swamp provide an important regional sanctuary and refuge for waterfowl.

Based on ground counts and aerial surveys, nine species of waterfowl have been observed in the Steel Creek delta area. The wood duck is the only species of waterfowl to breed commonly in the SRP region, and is present throughout the year. Wintering populations are larger than summer populations because of the influx of migratory wood ducks from the north. Wood ducks banded in the fall on the SRP site have been recovered in Minnesota, Wisconsin, and Ontario, as well as in South Carolina. In general, the remaining species are present only during the fall and/or winter months, although hooded mergansers may occasionally breed on the SRP site. In previous years, shovelers (Athya clypeata) and lesser scaup (A. affinis) have also been observed in the Steel Creek delta area (Angerman, 1979, 1980).

The mallard and wood duck dominated the Steel Creek delta area waterfowl community (Figure C-6). The frequency distribution of the number of each species observed was rather consistent, with mallards being dominant in all three years and wood ducks ranking second in two of three years. These two species also comprise the largest proportion of the hunter's bag in South Carolina. Use of the Steel Creek delta area by other species was generally low. Flocks of 50 green-winged teal, 25 American widgeon, 20 hooded mergansers, 1 pintail, and 1 bufflehead were observed during the fall and winter of 1981 and 1982.

Waterfowl used the Steel Creek delta extensively for both feeding and roosting (Figure C-7). Typically, they moved at dusk from the feeding grounds to a common roosting area where they spent the night. The roost area, which was

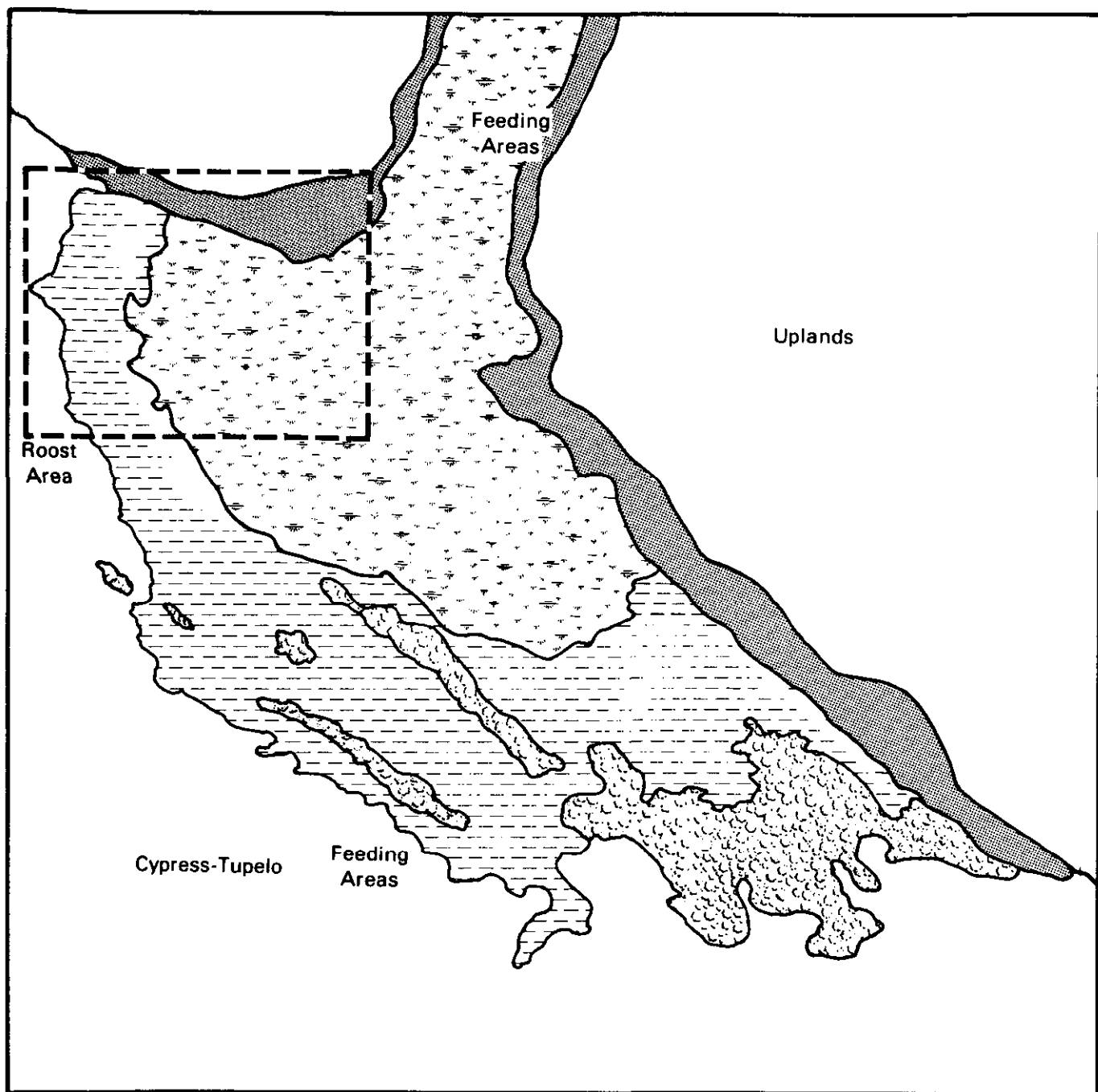


Legend:

MA - mallard	GWT - green-winged teal
WD - wood duck	BWT - blue-winged teal
WG - wigeon	PT - pintail
LS - lesser scaup	HM - hooded merganser
BL - black duck	SH - shoveler

Source: Smith et al. (1982a).

Figure C-6. Frequency distribution of waterfowl in the Steel Creek delta.



Legend:

Impacted



Deepwater (deeply flooded)



Deltaic fan (shallow flooded)

Nonimpacted



Bottomland hardwoods (seasonally flooded)



Upland (intermittently flooded)

Source: Smith et al. (1983).

Figure C-7. Feeding and roosting areas of waterfowl in the Steel Creek delta, fall 1981 and winter 1982. Zones influenced by L-Reactor operation (1954-1968) and associated hydrologic regimes are also shown.

characterized by dense buttonbush, provides good overhead protection from predators. In addition to numerous feeding areas in the delta (Figure C-7), waterfowl also fed extensively in the adjoining cypress-typelo forest.

Approximately 100 mallard were observed roosting in the Steel Creek delta in November and early December 1982 (Figure C-8). By mid-December, this number increased to 700. A minimum of 600 mallards roosted in the Steel Creek delta until March when numbers declined. The maximum number of mallards observed was slightly more than 1100 individuals on February 17, 1983.

The wood duck also roosted in the Steel Creek delta (Figure C-9) but in lesser numbers than mallards. Over 400 wood ducks were observed in January 1983 using the Steel Creek delta roosting area. Numbers declined in late January and leveled out through February and March.

Wood ducks have responded rapidly to the long-term nesting box program in the Steel Creek area. Studies have shown a general decline in the quality of nesting habitat in the Steel Creek area, but excellent brood habitat is present (Smith et al., 1981, 1982b).

Aerial surveys (Figure C-10) over the Steel Creek delta area, Pen Branch delta, Four Mile delta area, and Beaver Dam Creek revealed substantial use by mallards. However, waterfowl were never observed in Pen Branch delta. Mallard use of the Four Mile delta area in 1982 was generally higher than that of Steel Creek (Figure C-11). Mallards in the Four Mile delta area were associated with open channels that branch off the main delta at a 90° angle (Figure C-10). Mallards were observed in these channels whether C-Reactor was up or down except during the December 30 and January 5 surveys when C-Reactor was operating and the swamp water level reached a peak. During this period, the Savannah River had breached its levee and normal water flow across Four Mile delta was disrupted.

Hot water normally flows in a southwesterly direction across the delta toward the river and does not flow directly into the open channels. However, during peak water levels, hot water was probably diverted directly into the open channels making them unsuitable for use by waterfowl. Thus, the open channels associated with Four Mile delta were heavily used by waterfowl except during periods when normal water flow is disrupted.

During 1983, however, the number of mallards utilizing the Steel Creek delta area was markedly higher than Four Mile or Beaver Dam Creek (Figure C-11). This was attributable to consistently higher water levels and the greater availability of food.

These open channels exist because of the area's topography. Hardwood islands prevent the flow of hot water directly into these channels during periods of normal water levels. Around Pen Branch, similar open channels have not developed because of the different orientation of the hardwood islands. Although two hardwood islands are present in Steel Creek delta it is unlikely that suitable waterfowl habitat will develop between them after L-Reactor restart because flow from Steel Creek moves directly between the islands.

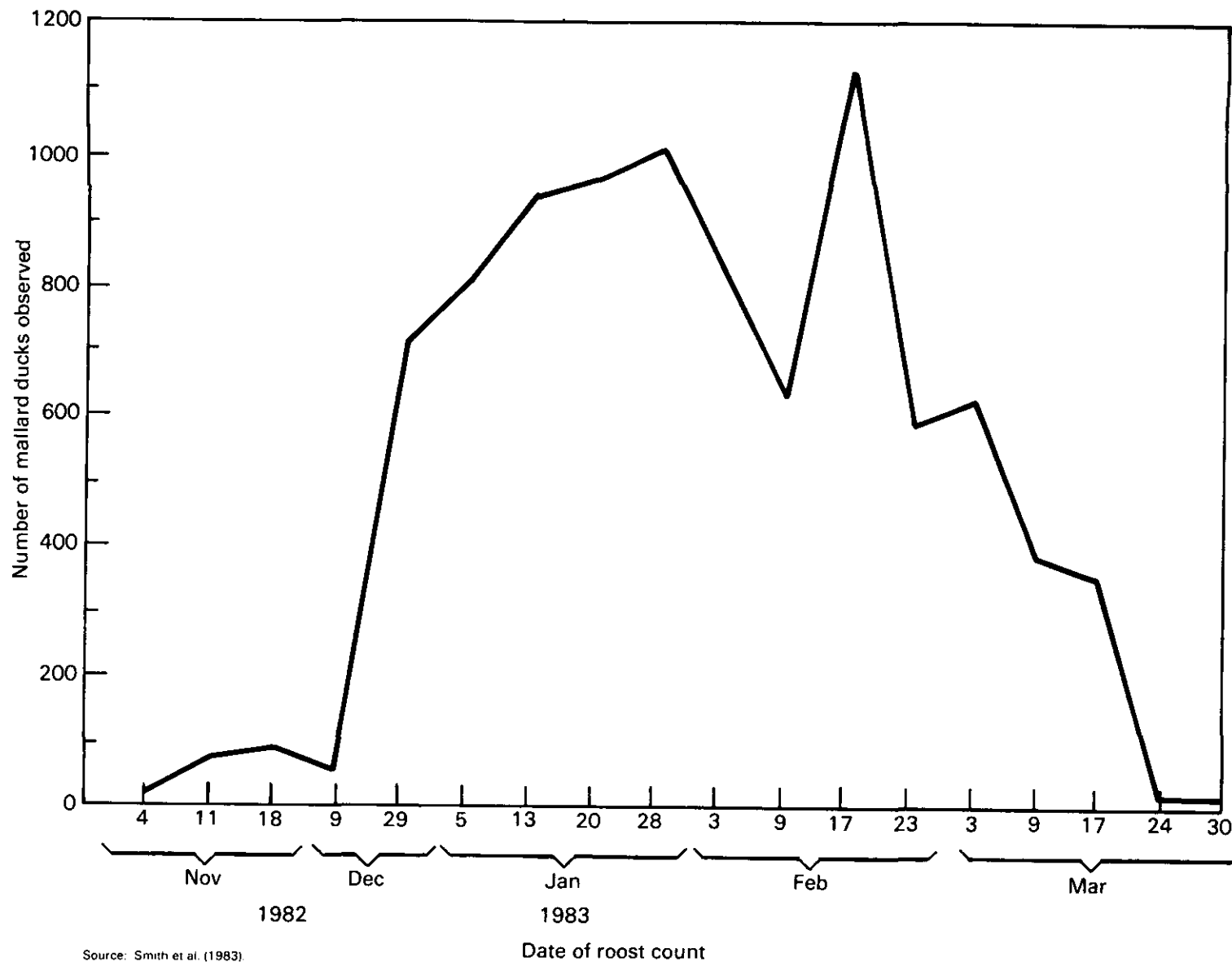


Figure C-8. Number of mallard ducks observed roosting in the Steel Creek delta, 1982-1983.

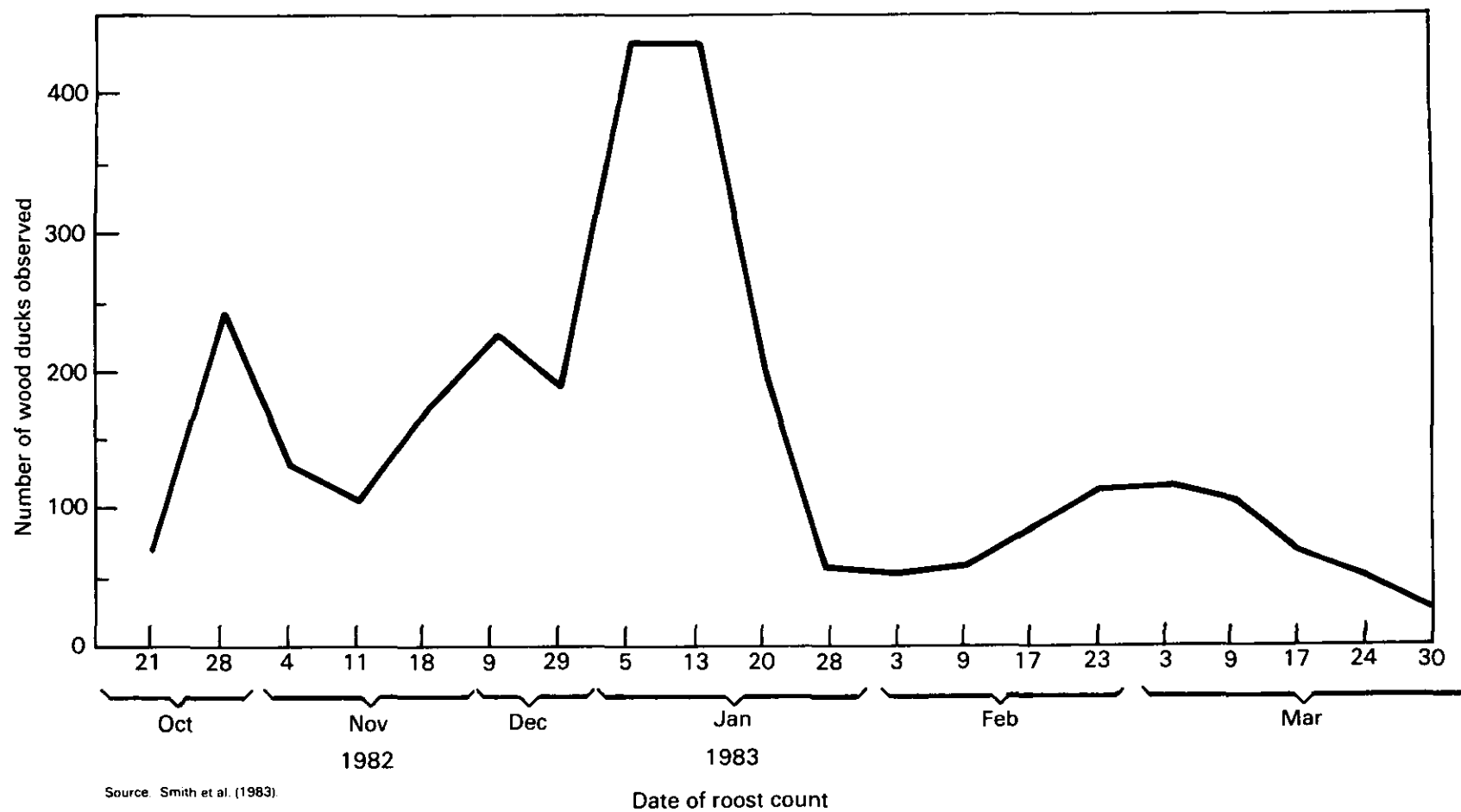
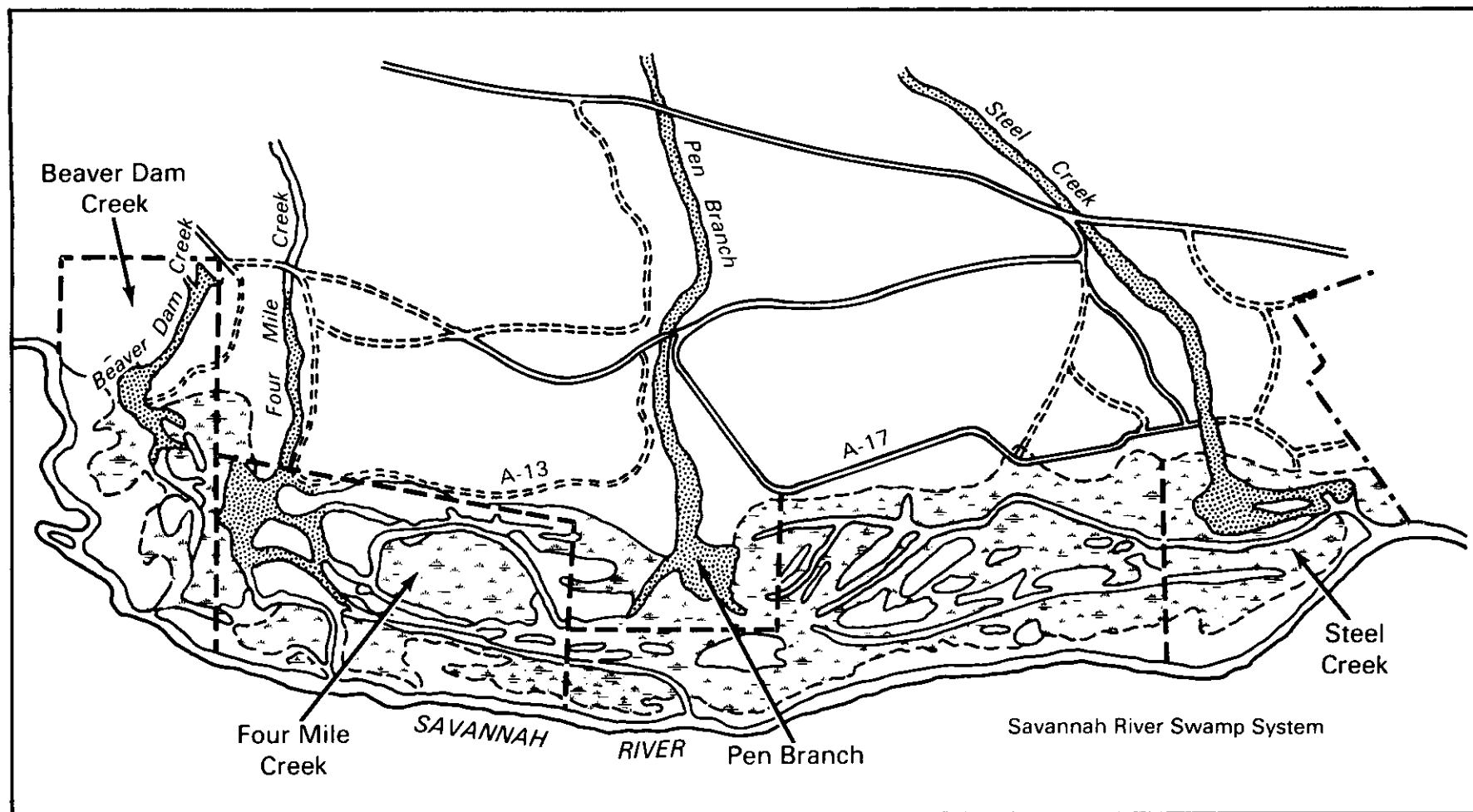


Figure C-9. Number of wood ducks observed roosting in the Steel Creek delta, 1982-1983.



Legend:

- | | |
|---|---|
|  Islands |  River, creeks |
|  Thermal areas |  Roads |
|  Swamp areas | |

0 1 2 3 4 5 6 7 8 kilometers



Source: Smith et al. (1983)

Figure C-10. Areas of the Savannah River swamp censused for waterfowl during fall 1981 and winter 1982.

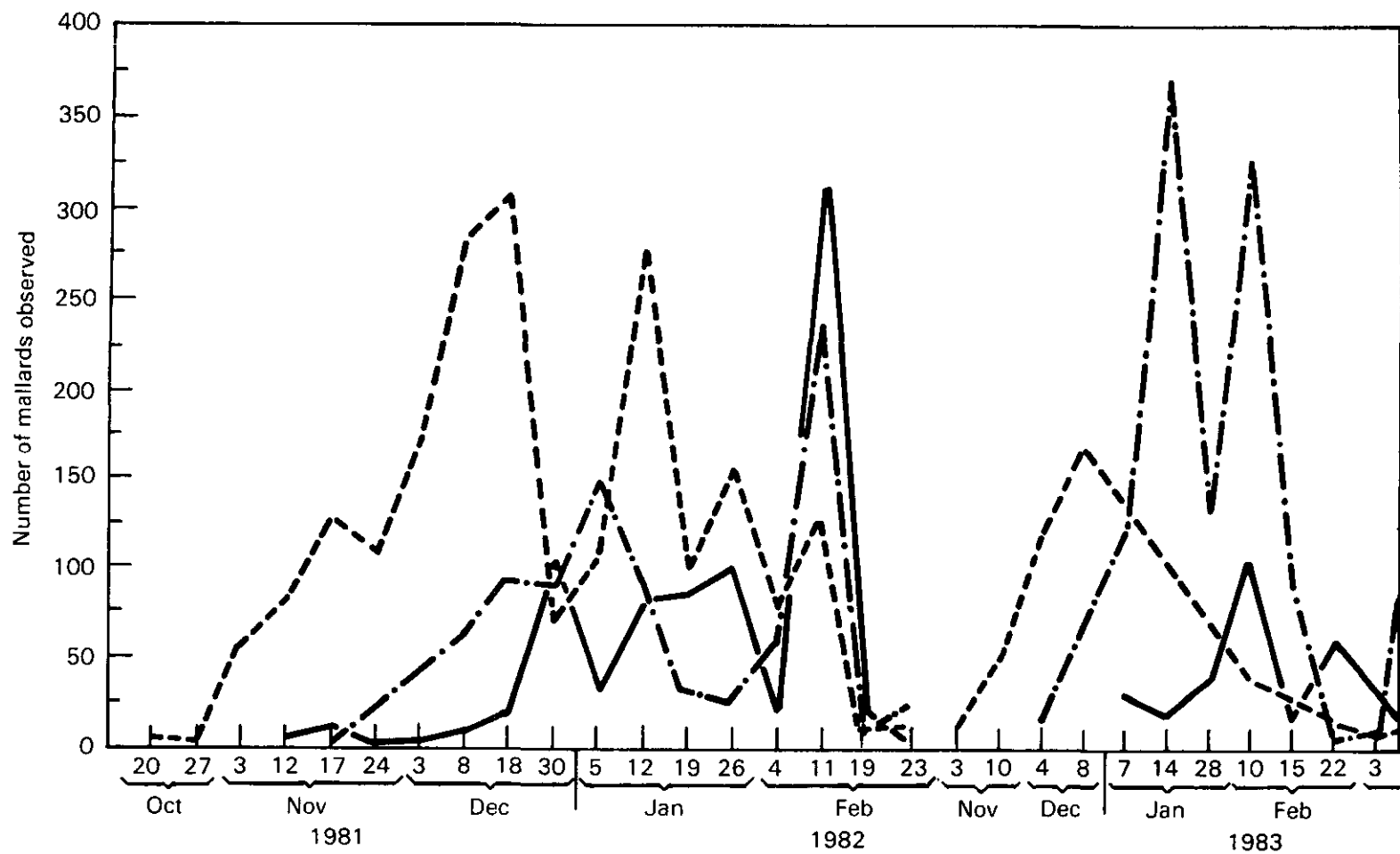


Figure C-11. Number of mallards observed in Four Mile Creek, Beaver Dam, and Steel Creek deltas during fall 1981 and winter 1982.

Wood stork

The wood stork, which is the only "true" stork to nest in the United States, has experienced a 75-percent decline in its population since the 1930s. It is classified as endangered by the State of South Carolina and the U.S. Fish and Wildlife Service (Federal Register, 1984).

AD-3

Although the wood stork once nested throughout the coastal region of the southeastern United States from Texas to South Carolina, (Palmer, 1962) they currently nest only in Florida and Georgia. The most northern rookery in the United States, the Birdsville rookery, is in Jenkins County, Georgia; it was discovered in July 1980. The cypress swamp surrounding the Birdsville colony is privately owned. At present the Georgia Department of Natural Resources leases the land and patrols the stork colony.

AD-1,
AD-3,
AY-2

Two wood storks were observed in the Savannah River swamp in 1981; one bird was sighted between Pen Branch and Four Mile Creek deltas, and one was observed between Steel Creek and Pen Branch deltas. Since these sightings were recorded, more intensive surveys using aerial censuses and habitat analysis have been conducted by the Savannah River Ecology Laboratory.

Wood storks were sighted on 14 different dates between May 31 and September 3, 1982 (Table C-7). Of the 53 individuals that were observed flying and foraging, all but 3 observations occurred in the Steel Creek delta.

AD-1,
AD-3,
AY-2

A total of 478 wood stork observations were made on the SRP site in summer 1983. These surveys showed that large concentrations of wood storks foraged in the swamp near Steel Creek and Beaver Dam Creek deltas (Table C-7). Small numbers were also recorded for Four Mile Creek and Pen Branch deltas. Wood storks have been followed from the Birdsville rookery to the Savannah River Plant, a distance of 45 kilometers, where they foraged in the swamp.

The sightings of wood storks in Steel Creek delta corresponded closely with wood stork activity at the Birdsville rookery. In July 1980, 200 nesting wood storks were present at this rookery (Georgia Department of Natural Resources, 1980), and more than 20 wood storks were seen at one time over Steel Creek delta. In 1981, wood storks at the Birdsville rookery did not complete the nesting cycle, and by June 6, 1981, only three storks remained there (Georgia DNR, 1981). Only four wood stork sightings were made in 1981. However, approximately 115 to 130 adult wood storks were present at the Birdsville rookery from April through July 1982, and nests were observed to contain feathered young. In 1983, a total of 238 breeding adults was present at the Birdsville rookery; this corresponded to the maximum number of 478 recorded observations at the Savannah River Plant.

The Birdsville rookery produced more than two wood storks per nest in 1983 (Table C-8). A productivity of 1.7 storks per nest is considered adequate to maintain stork population levels (Ogden and Patty, 1981). Many of the nests at Birdsville in 1983 contained three young (one contained four), which indicates that food resources were abundant at feeding areas.

AD-1,
AD-3,
AY-4

Foraging sites in the SRP Savannah River swamp system ranked significantly higher ($P < 0.05$) than other sites when comparing the mean number of storks

Table C-7. Date, number, and locations of wood storks observed on the Savannah River Plant site, 1982 and 1983^a

Date	Number observed	Location
1982		
May 31	2	Bulldog Bay
June 11	1	Steel Creek delta
June 15	1	Steel Creek delta
June 18	1	P-Reactor
June 23	1	Steel Creek delta
June 25	1	Steel Creek delta
June 29	5	Steel Creek delta
July 1	1	Steel Creek delta
July 20	1	Steel Creek delta
July 22	1	Steel Creek delta
August 6	2	Steel Creek delta
August 27	14	Steel Creek delta
September 2	11	Steel Creek delta
September 3	11	Steel Creek delta
1983		
June 23	5	Pen Branch swamp
June 25	2	Four Mile swamp
June 28	2	Steel Creek delta
June 30	23	Steel Creek delta
July 1	29	Steel Creek delta
July 1	28	Beaver Dam Creek swamp
July 2	32	Beaver Dam Creek swamp
July 2	36	Pen Branch swamp
July 11	43	Steel Creek delta
July 12	17	Beaver Dam Creek swamp
July 12	5	Steel Creek delta
July 12	3	Pen Branch delta
July 13	195	Beaver Dam Creek swamp
July 14	30	Beaver Dam Creek swamp
July 25	1	Beaver Dam Creek swamp
July 27	1	Beaver Dam Creek swamp
July 27	2	Four Mile Creek swamp
July 28	1	Four Mile Creek swamp
July 30	3	Pen Branch swamp
August 1	11	Beaver Dam Creek swamp
August 3	9	Four Mile Creek swamp

^aAdapted from Smith et al. (1982a, 1983).

Table C-8. Results of wood stork nest survey,
Birdsville, Georgia

Year	Number of active nests	Mean number of young per nest ^a
1980	100 ^b	2 ^b
1981	failed	0
1982	60 ^b	no data
1983	113 ^c	2.19 ^c

^aYoung at least 5 weeks old.

^bEstimated from ground or aerial surveys.

^cActual count from 26 nest trees.

observed at all SRP sites (29.8) with those observed at other sites (8.4) before fledging (Table C-9). After fledging, juveniles and adults were recorded foraging at non-SRP sites. Juveniles did not use SRP foraging sites. Foraging sites at the Steel Creek delta attracted an average of 19.3 storks, which was not statistically higher ($P > 0.05$) than the average of 8.4 storks observed at other sites not located on the SRP.

After July 12, 1983, wood storks were not recorded in the Steel Creek delta, even though they were present at other SRP sites (Table C-7). On this date or soon thereafter, the water depth at site 012 in the Steel Creek delta increased to 48 centimeters (from 18 centimeters) due to cold-flow testing at L-Reactor. Depths at site 012 remained between 44 and 48 centimeters through September 1983. High water resulting from SRP reactor testing prevented storks from feeding because the fish that were originally concentrated in shallow pools had dispersed.

A majority of the wood stork's foraging sites (39 percent) were within 10 kilometers of the Birdsville colony. Surveys indicated that only a few sites were found greater than 50 kilometers from the colony. However, 24 percent of the sites were located between 40 and 50 kilometers from Birdsville. This includes the foraging sites at SRP swamps. These results indicate that the Savannah River Swamp, particularly the deltas of Beaver Dam Creek and Steel Creek, represent important feeding habitat for wood storks of the Birdsville rookery.

A recent biological assessment on the wood stork was submitted to FWS for their consideration (Sires, 1984b). The assessment concluded that the proposed L-Reactor operation and 1000-acre lake construction and operation would not jeopardize the continued existence of the wood stork.

AD-1,
AD-3,
AY-2

Table C-9. Mean number of wood storks observed foraging at SRP sites and other sites before and after fledging of young from the Birdsville, Georgia, colony

Site	Number of sites	Mean ^a	S.D.
SRP SAVANNAH RIVER SWAMP SYSTEM SITES ^b			
Beaver Dam Creek	5	37.2	30.3
Pen Branch	1	24.0	--
Steel Creek	3	19.3	15.5
All SRP sites	9	29.8	24.5
OTHER SITES (NOT LOCATED ON SRP)			
Before fledging	18	8.4	7.1
After fledging	23	14.3	14.6
Total sites	50	14.5	16.4

^aMean based on maximum number of storks observed at each site.

^bStorks foraged at SRP swamps only before fledging (July 25 to 28, 1983).

C.3.3 Mammals

More than 40 species of mammals have zoogeographic ranges that include the Savannah River Plant (Burt and Grossenheider, 1976; Golley, 1966); 25 of these are known to occur near Steel Creek (Smith et al., 1981). The presence of two additional species, the muskrat (Ondatra zibethica) and the black bear (Ursus americanus), was confirmed near Steel Creek, even though their documented ranges do not include Savannah River Plant. Transient occurrences along the river floodplains by the black bear are not considered uncommon.

Based on the use of drift fences, pitfall traps, and the board transects during the summer of 1981, the short-tailed shrew (Blarina brevicauda), the least shrew (Cryptotis parva), and the southeastern shrew (Sorex longirostris) were determined to be the most frequently captured small mammals. The Steel Creek delta provided habitat for the rice rat (Oryzomys palustris), and the eastern wood rat (Neotoma floridana) and hispid cotton rat (Sigmodon hispidus) also occur there. The gray squirrel (Sciurus carolinensis), fox squirrel (Sciurus niger), and southern flying squirrel (Glaucomys volans) were common in the upland and lowland forests along Steel Creek. Large mammals, such as the feral pig (Sus scrofa) and the white-tailed deer (Odocoileus virginianus), were common on the Steel Creek floodplain and delta. Other inhabitants of the floodplain and delta included the raccoon (Procyon lotor), opossum (Didelphis

marsupialis), and gray fox (Urocyon cinereoargenteus). Signs of the beaver (Castor canadensis) were common along the length of Steel Creek and one dead individual was observed between Road A and Cypress Bridge.

C.4 AQUATIC BIOTA

Six major aquatic habitat types occur on the SRP site: small ponds, Carolina bays, reservoirs, streams, and the Savannah River and its associated floodplain swamp. The standing waters vary in size from less than 1 acre to about 2800 acres. Flows in the various streams range from less than 0.028 to 11 cubic meters per second.

The floodplain swamp, which includes the Steel Creek delta, bordering the river is the least known aquatic habitat on the Savannah River Plant. Its possible use as spawning and rearing grounds and as nutrient sink are largely unknown. It is quite diverse as distinct water courses alternate with braided channels and broad flats of barely perceptible water movement. It is also one of the most variable habitats, experiencing depth fluctuations of 4 meters or more and, also, the input of thermal effluent from three SRP sources.

C.4.1 Aquatic flora

In running-water environments like the Savannah River, attached algae (periphyton) are the predominant primary producers. Much of the phytoplankton (floating algae) community consists of true planktonic forms as well as detached periphytic forms that are discharged from upstream reservoirs and from backwaters and tributary streams.

The algal flora of the Savannah River are dominated by diatoms, although blue-green algae are at times an important component, particularly at upstream locations that are subject to organic enrichment from municipal effluents from the communities of Augusta and Horse Creek Valley. The greatest algal diversity consistently occurs during the summer, coincident with low river flow and decreased turbidity, which allows greater light penetration.

Approximately 400 species of algae have been identified from the Savannah River near the Savannah River Plant (Patrick et al., 1967). Since 1951, when algal studies began, diversity has decreased. Patrick et al. (1967) suggested that this reflects an increase of organic loading to the river from the area above the Savannah River Plant (ANSP, 1961; 1974).

Aquatic macrophytes in the river, most of which are rooted, are limited to shallow areas of reduced current and along the shallow margins of tributaries. Eight species of vascular plants have been identified from the river adjacent to the Savannah River Plant, the most abundant being water milfoil, hornwort, alligatorweed, waterweed, and duck potato (Georgia Power Company, 1974).

In the SRP streams that receive thermal effluents, the flora are greatly reduced, reflecting the influence of high flows and elevated (greater than 40°C)

water temperatures. In these areas, thermophilic bacteria and blue-green algae thrive where no other aquatic life occurs.

Vegetation mapping of the Steel Creek delta and swamp conducted by the Savannah River Ecology Laboratory (Smith et al., 1981) revealed a deepwater zone where the main flow of Steel Creek courses toward the Savannah River and the hardwood canopy is reduced. In this area, the vegetation was dominated by submergent and emergent macrophytes. Patches of duckweed (*Lemna perpusilla*) collected on mats of submerged vascular plants such as hornwort (*Ceratophyllum demersum*) and parrotfeather (*Myriophyllum brasiliense*) that root on subsurface logs, trees, and stumpbases. Where the water flow was slow-moving, *Polygonum* spp. formed dense colonies.

C.4.2 Aquatic fauna

C.4.2.1 Macroinvertebrates

Shallow areas and quiet backwaters of the Savannah River near the SRP site supported diverse aquatic invertebrate assemblages; however, the bottom substrate of most open portions of the river consisted of shifting sand that does not provide optimum habitat for bottom-dwelling organisms. The total number of invertebrate species occurring in the river decreased sharply during the 1950s which has been attributed primarily to the effects of dredging (Patrick et al., 1967). The stabilization of river discharges and the elimination of habitat caused by the reduction in flooding of backwater areas, as well as organic loading above Savannah River Plant, might also have contributed to the decline. Some recovery occurred during the early 1960s, but complete recovery has not taken place. The groups most affected were those sensitive to the effects of siltation and substrate instability. Of the insect fauna, mayflies and dragonflies had the largest number of species in earlier surveys. Since the decline in species between 1955 and 1960, dipterans (true-flies) have been represented by the most species.

To evaluate the effects of thermal loading to SRP streams, Howell and Gentry (1974) compared the aquatic insect populations of Upper Three Runs Creek (natural stream), Pen Branch (thermal stream), and Steel Creek (post-thermal stream). The Pen Branch stream had overflowed its banks with heated water, causing a floodplain in which the trees had been killed. This led to exposure of the stream to direct sunlight. There was also considerable siltation. The macroinvertebrate associations in Pen Branch were characterized by low diversity and low evenness. The absence of caddisflies, stoneflies, and mayflies in this stream indicated that a significant portion of the natural aquatic insect community had been eliminated by thermal effects. The few remaining insect populations were large, which is indicative of thermal influence.

Between March 13 and August 29, 1982, the macroinvertebrate drift community was sampled as part of the Biological Measurement Program in the Savannah River (ECS, 1983b). Sample sites included the Savannah River, the pumphouse intake canals, as well as the mouths of Upper Three Runs Creek, Four Mile Creek and Steel Creek. A total of 131,815 macroinvertebrates was collected representing 47 insect families and 6 non-insect groups.

The most abundant insect family collected was the true-fly family, chironomidae (midges), which comprised 66.2 percent of the total macroinvertebrates collected. Macroinvertebrate drift communities with a predominance of true-flies are typical of riverine habitats.

Other abundant taxa included mayflies, caddisflies, scuds, water mites and nematode worms. When the invertebrate community was examined with respect to functional feeding groups, insect collectors (which feed on small organic particles in the water) were found to be the most abundant functional group, accounting for 64 to 85 percent of the organisms collected. Non-insect piercers (which feed by sucking plant juices), consisting entirely of water mites; these were very abundant in the canals, and comprised 13 to 18 percent of the invertebrate fauna. Snails were infrequently found in the drift samples, although they are abundant in the river.

In general, samples from the pumphouse intake canals and the creeks contained significantly fewer taxa than did the river samples. The mean density of macroinvertebrates was also less in the canals and Upper Three Runs Creek and Steel Creek than in the river.

There were fewer true-flies and caddisflies in the canals and more beetles and water mites, based on qualitative collections. True-flies were less abundant in creeks than the river. Upper Three Runs Creek had higher percentages of mayflies, caddisflies, beetles and stoneflies than river collections, but no scuds. Four Mile Creek, which is thermally affected, had a high percentage of mayflies, mostly Caenidae, but low percentage of caddisflies, beetles and water mites. Steel Creek, which has heated water from Pen Branch in its lower one kilometer, had more abundant scuds than the river transects.

An investigation of the aquatic invertebrate communities living on wood substrates and submerged macrophytes in the Steel Creek stream-swamp ecosystem was conducted by the Savannah River Ecology Laboratory in the upper and lower reaches of Steel Creek and in the floodplain swamp (Smith et al., 1982b). The habitats were selected based on preliminary investigations and current literature that showed them to be the most diverse, to have the highest productivity and to be the most closely associated with fish trophic dynamics in the swamp.

Sampling sites of snags were located along a continuum from the rapidly flowing sections of Steel Creek above the floodplain swamp, through the swamp to the lower portion of the creek, which flows rapidly from the swamp to the Savannah River. Results of collections revealed significant differences between sampling sites in terms of species density, richness and colonization patterns. Many of the same invertebrate taxa occurred at the sampling sites in upper and lower Steel Creek, although organism density and diversity were much higher in the upper reach than in the lower reach and were lowest in the swamp. An abundant macroinvertebrate population was also associated with macrophyte beds in the swamp. Abundance varied significantly between plant species and was generally dominated by amphipods. These invertebrate populations on macrophytes may form a significant source of fish food in the swamp.

C.4.2.2 Fish

Like other typical southeastern coastal plain rivers and streams, the Savannah River and its associated swamp and tributaries have a diverse fish fauna. Descriptions of the fishes of the Savannah River have been included in many ecological studies during the last 30 years. Matthews (1982) reviewed those studies published by the Academy of Natural Sciences of Philadelphia between 1951 and 1976. The results of fisheries studies in the portion of the river near the Savannah River Plant were reported by McFarlane et al. (1978a) and Dudley et al. (1977). Additionally, the Georgia Game and Fish Division (1982) reported on an electrofishing survey they conducted at 24 locations in the Savannah River between the New Savannah River Bluff Lock and Dam and Port Wentworth. Data on anadromous species, many of which are important in the Savannah River, were compiled by Rulifson et al. (1982).

Steel Creek studies

Studies of fish populations in the Steel Creek delta-swamp system and the Savannah River adjacent to the SRP showed a high species diversity (ECS, 1983a, 1983b, Smith et al., 1982b, 1983) (Tables C-10 and C-11).

The highest abundance and diversity of fish in Steel Creek occurred in deepwater areas where the tree canopy was eliminated during previous reactor operations and the vegetation was dominated by submergent and emergent macrophytes.

The use of the Steel Creek delta-swamp area by anadromous fish species (e.g., American shad and blueback herring) was minimal during 1982. Only 10 individuals of both species were collected. The appearance of American shad in Steel Creek was late in 1982 and the numbers were quite small. However, it appears that the shad spawning run in the Savannah River was smaller than in previous years; large year-to-year variations in abundance of anadromous fish species are quite common. In 1983, the American shad and blueback herring spawning run in Steel Creek occurred earlier than in 1982 (February through April for blueback herring and late March through May for American shad) (Smith et al., 1983). There was a greater utilization of the Steel Creek delta-swamp area by adult shad and blueback herring in 1983 as compared to 1982 (76 shad in 1983 versus 6 in 1982; 124 blueback herring in 1983 versus 4 in 1982). Two striped bass were collected in the delta-swamp area in 1983 while none were collected in 1982 (Smith et al., 1983).

During 1982, ichthyoplankton sampling revealed no evidence of spawning by shad, blueback herring, or striped bass in upper Steel Creek and the Steel Creek delta. However, ichthyoplankton of all three species was collected from the mouth of Steel Creek.

In 1983, Steel Creek yielded 518 fish larvae and 103 eggs in 23 ichthyoplankton collections made between March and August. The larvae were predominantly minnows, yellow perch, and sunfish and bass. Many blueback herring eggs were also collected. When compared to other creeks that were sampled ten or more times, Steel Creek ranked eighth in larval density of all species combined. This creek was distinctive in having minnows and yellow perch represent about 27 and 30 percent, respectively, of the fish larvae collected here. In all other streams of a similar size, these two species comprised no more than

AY-7,
EZ-1,
EZ-5

Table C-10. Scientific and common names of fish collected in the Steel Creek river-swamp, October 1981-July 1982^a

Scientific name	Common name
Amblyopsidae	
<u>Chologaster cornuta</u>	Swampfish
Amiidae	
<u>Amia calva</u>	Bowfin
Anguillidae	
<u>Anguilla rostrata</u>	American eel
Aphredoderidae	
<u>Aphredoderus sayanus</u>	Pirate perch
Atherinidae	
<u>Labidesthes sicculus</u>	Brook silverside
Belonidae	
<u>Strongylura marina</u>	Atlantic needlefish
Catostomidae	
<u>Erimyzon oblongus</u>	Creek chubsucker
<u>Erimyzon sucetta</u>	Lake chubsucker
<u>Minytrema melanops</u>	Spotted sucker
Centrarchidae	
<u>Centrarchus macropterus</u>	Flier
<u>Elassoma zonatum</u>	Banded pygmy sunfish
<u>Enneacanthus chaetodon</u>	Blackbanded sunfish
<u>Enneacanthus gloriosus</u>	Bluespotted sunfish
<u>Lepomis auritus</u>	Redbreast sunfish
<u>Lepomis gulosus</u>	Warmouth
<u>Lepomis macrochirus</u>	Bluegill
<u>Lepomis microlophus</u>	Redear sunfish
<u>Lepomis punctatus</u>	Spotted sunfish
<u>Micropterus salmoides</u>	Largemouth bass
<u>Pomoxis annularis</u>	White crappie
<u>Pomoxis nigromaculatus</u>	Black crappie
Clupeidae	
<u>Alosa sapidissima</u>	American shad
<u>Alosa aestivalis</u>	Blueback herring
<u>Dorosoma cepedianum</u>	Gizzard shad
Cyprinidae	
<u>Cyprinus carpio</u>	Carp
<u>Hyboganthus nuchalis</u>	Silvery minnow
<u>Notemigonus crysoleucas</u>	Golden shiner
<u>Notropis chatybaeus</u>	Ironcolor shiner
<u>Notropis cummingsae</u>	Dusky shiner
<u>Notropis emiliae</u>	Pugnose minnow
<u>Notropis hudsonius</u>	Spottail shiner
<u>Notropis leedsi</u>	Bannerfin shiner
<u>Notropis lutipinnis</u>	Yellowfin shiner
<u>Notropis maculatus</u>	Taillight shiner
<u>Notropis niveus</u>	Whitefine shiner
<u>Notropis petersoni</u>	Coastal shiner

Table C-10. Scientific and common names of fish collected in the Steel Creek river-swamp, October 1981-July 1982^a (continued)

Scientific name	Common name
<u>Cyprinodontidae</u>	
<u>Fundulus lineolatus</u>	Lined topminnow
<u>Esocidae</u>	
<u>Esox americanus</u>	Redfin pickerel
<u>Esox niger</u>	Chain pickerel
<u>Ictaluridae</u>	
<u>Ictalurus natalis</u>	Yellow bullhead
<u>Ictalurus nebulosus</u>	Brown bullhead
<u>Ictalurus platycephalus</u>	Flat bullhead
<u>Ictalurus punctatus</u>	Channel catfish
<u>Noturus gyrinus</u>	Tadpole madtom
<u>Noturus leptacanthus</u>	Speckled madtom
<u>Lepisosteidae</u>	
<u>Lepisosteus osseus</u>	Longnose gar
<u>Lepisosteus platyrhincus</u>	Florida gar
<u>Mugilidae</u>	
<u>Mugil cephalus</u>	Striped mullet
<u>Percichthyidae</u>	
<u>Morone saxatilis</u>	Striped bass
<u>Percidae</u>	
<u>Etheostoma fusiforme</u>	Swamp darter
<u>Etheostoma olmstedii</u>	Tessellated darter
<u>Perca flavescens</u>	Yellow perch
<u>Percina nigrofasciata</u>	Blackbanded darter
<u>Poeciliidae</u>	
<u>Gambusia affinis</u>	Mosquitofish
<u>Umbridae</u>	
<u>Umbra pygmaea</u>	Eastern mudminnow

^aAdapted from Smith et al. (1982b).

Table C-11. Fish species collected during adult fisheries study, Savannah River Plant: August 1982, October 1982, and January 1983a

Scientific name	Common name
<u>Acipenser oxyrhynchus</u>	Atlantic sturgeon
<u>Lepisosteus osseus</u>	Longnose gar
<u>Amia calva</u>	Bowfin
<u>Anguilla rostrata</u>	American eel
<u>Alosa aestivalis</u>	Blueback herring
<u>Alosa mediocris</u>	Hickory shad
<u>Alosa sapidissima</u>	American shad
<u>Dorosoma cepedianum</u>	Gizzard shad
<u>Dorosoma pretenense</u>	Threadfin shad
<u>Esox americanus</u>	Redfin pickerel
<u>Esox niger</u>	Chain pickerel
<u>Cyprinus carpio</u>	Carp
<u>Hybognathus nuchalis</u>	Silvery minnow
<u>Hybopsis rubifrons</u>	Rosyface chub
<u>Nocomis leptcephalus</u>	Bluehead chub
<u>Notimogonus crysoleucas</u>	Golden shiner
<u>Notropis chalybaeus</u>	Ironcolor shiner
<u>Notropis emiliae</u>	Pugnose minnow
<u>Notropis hudsonius</u>	Spottail shiner
<u>Notropis leedsi</u>	Ochoopee shiner
<u>Notropis maculatus</u>	Taillight shiner
<u>Notropis niveus</u>	Whitefin shiner
<u>Notropis petersoni</u>	Coastal shiner
<u>Erimyzon sucetta</u>	Lake chubsucker
<u>Minytrema melanops</u>	Spotted sucker
<u>Moxostoma anisurum</u>	Silver redhorse
<u>Ictalurus brunneus</u>	Snail bullhead
<u>Ictalurus catus</u>	White catfish
<u>Ictalurus nebulosus</u>	Brown bullhead
<u>Ictalurus platycephalus</u>	Flat bullhead
<u>Ictalurus punctatus</u>	Channel catfish
<u>Noturus leptacanthus</u>	Speckled madtom
<u>Aphredoderus sayanus</u>	Pirate perch
<u>Fundulus notti</u>	Starheaded topminnow
<u>Gambusia affinis</u>	Mosquitofish
<u>Labidesthes sicculus</u>	Brook silverside
<u>Morone saxatilis</u>	Striped bass
<u>Acantharchus pomotis</u>	Mud sunfish
<u>Centrarchus macropterus</u>	Flier
<u>Lepomis auritus</u>	Redbreast sunfish
<u>Lepomis gibbosus</u>	Pumpkinseed
<u>Lepomis gulosus</u>	Warmouth
<u>Lepomis macrochirus</u>	Bluegill
<u>Lepomis marginatus</u>	Dollar sunfish
<u>Lepomis microlophus</u>	Redear sunfish
<u>Lepomis punctatus</u>	Spotted sunfish
<u>Micropterus salmoides</u>	Largemouth bass

Table C-11. Fish species collected during adult fisheries study, Savannah River Plant: August 1982, October 1982, and January 1983^a (continued)

Scientific name	Common name
<u>Pomoxis annularis</u>	White crappie
<u>Pomoxis nigromaculatus</u>	Black crappie
<u>Etheostoma olmstedii</u>	Tessellated darter
<u>Perca flavescens</u>	Yellow perch
<u>Percina nigrofasciata</u>	Blackbanded darter
<u>Agonostomus monticola</u>	Mountain mullet
<u>Mugil cephalus</u>	Striped mullet
<u>Trinectes maculatus</u>	Hogchoker

^aAdapted from ECS (1983a,b,c).

about 13 and 7 percent of the total larvae, respectively. In Steel Creek, densities of crappie larvae relative to other species were much lower than in the other large streams sampled.

Much more fish spawning occurred in Four Mile Creek in 1983 than in 1982, apparently because high river levels reversed stream flow enough to allow fish to enter the creek. A high density of larvae, mostly blueback herring, was observed on April 4, 1983. However, similar medium-sized streams that were sampled had higher larval densities and longer spawning periods than Four Mile Creek. Apparently, the elevated water temperature in this stream was a factor that limited spawning.

The diversity and abundance of fish in the thermally affected SRP streams was high only during periods of reactor shutdown (McFarlane, 1976). In addition, the fauna upstream of the thermal effluents was depauperate in both numbers and diversity. With the exception of the mosquitofish (Gambusia affinis), few fish lived in the streams when thermal effluent was present. During reactor shutdown, the streams return to ambient temperature and are invaded immediately by many fish from adjacent nonthermal areas. The diversity and abundance of species in the headwater tributaries of Four Mile Creek and Pen Branch upstream from reactor thermal effluents were reduced greatly in contrast to comparable areas in Upper Three Runs Creek or Steel Creek (McFarlane, 1976). Collection efforts have revealed that the first- and second-order tributaries of these streams were essentially devoid of fish.

To evaluate the potential for the entrainment of young stages of fish in the cooling-water systems, an ichthyoplankton sampling program was conducted in the river from March to August 1977 (McFarlane et al., 1978a). Fish eggs occurred in the collections during each month of the study. The greatest densities occurred in May. American shad comprised 96 percent of all fish eggs collected during the study. More than 1700 fish larvae representing at least 22 species were identified from the plankton collections. The greatest larval densities occurred in April. Clupeidae, primarily blueback herring, accounted for more than half of the larvae collected. Other abundant species were spotted sucker, black crappie, cyprinids, and channel catfish. The greatest number of

fish larvae were collected in Upper Three Runs Creek and in the 1G and 3G intake canals.

Savannah River fisheries program

The Biological Measurement Program in the Savannah River initiated in March 1982 was designed to provide additional data on the biological communities in the river that might be affected by the present and proposed activities at the Savannah River Plant. The long-term study of the river encompasses many factors including fish populations, meroplankton communities, and fish impingement at the SRP pumphouse intake screens. This section summarizes the results of the meroplankton and impingement sampling conducted from March through August 1982 and from February through July 1983 and electrofishing collections made in August and October 1982 and January 1983 (ECS, 1982, 1983a,b,c,d). A preliminary report (ECS, 1983d) describes portions of the 1983 results.

Meroplankton collections were made at nine transects and three creek stations during March through August 1982. The approximate locations of the sampling points are shown in Figures C-12 and C-13.

Larval fish populations in the region of the Savannah River sampled in 1982 were clearly dominated by the herring and shad family (Clupeidae). The herring and shad larvae combined made up almost 50 percent of all fish larvae collected (Table C-12). On 13 sampling dates between March 11 and August 29, 1982, a total of 2138 samples was collected. When these samples were sorted and analyzed, 10,205 ichthyoplankton were removed, identified and counted. Of this total, 50.7 percent were fish larvae and 49.3 percent were fish eggs.

In 1982, spawning for most Savannah River fishes occurred between early March and late July. On March 11-12, only 12 larval fishes were collected, which indicates that this sampling was prior to the main spawning period for most species. On March 25-26, 285 larval fish were collected. At that time, spotted suckers were the dominant larval form, constituting 42.8 percent of the total collection. On April 7-8, the minnows, which had not been taken in the prior collection, constituted almost 50 percent of the collection. Spotted suckers were again very abundant in April, making up 28.2 to 41.4 percent of the fish larvae collected. Minnows continued to dominate the collections from early April until May 20-21, when the number of unidentified clupeids increased to 43.0 percent of the total of 2268 larval fishes collected. Unidentified clupeids continued to dominate the larval collection through June, while minnows were almost absent from these collections. In July and August, the number of fish larvae collected was low.

During the survey, eggs of several important species (American shad, striped bass, and blueback herring) were identified. Eggs of these three species constituted 90 percent of the total eggs collected (Table C-13). Of the 5029 fish eggs collected during this study, 3550 were those of the American shad, about 71 percent of the eggs collected. McFarlane et al. (1978a) reported that over 96 percent of the fish eggs collected in their 1977 study were American shad. In the 1982 investigation, striped bass was the second most abundant fish egg collected. A total of 494 striped bass eggs was collected, which represents about 10 percent of all eggs collected during the study. Striped bass spawning had not been documented in the central Savannah River prior to 1982.

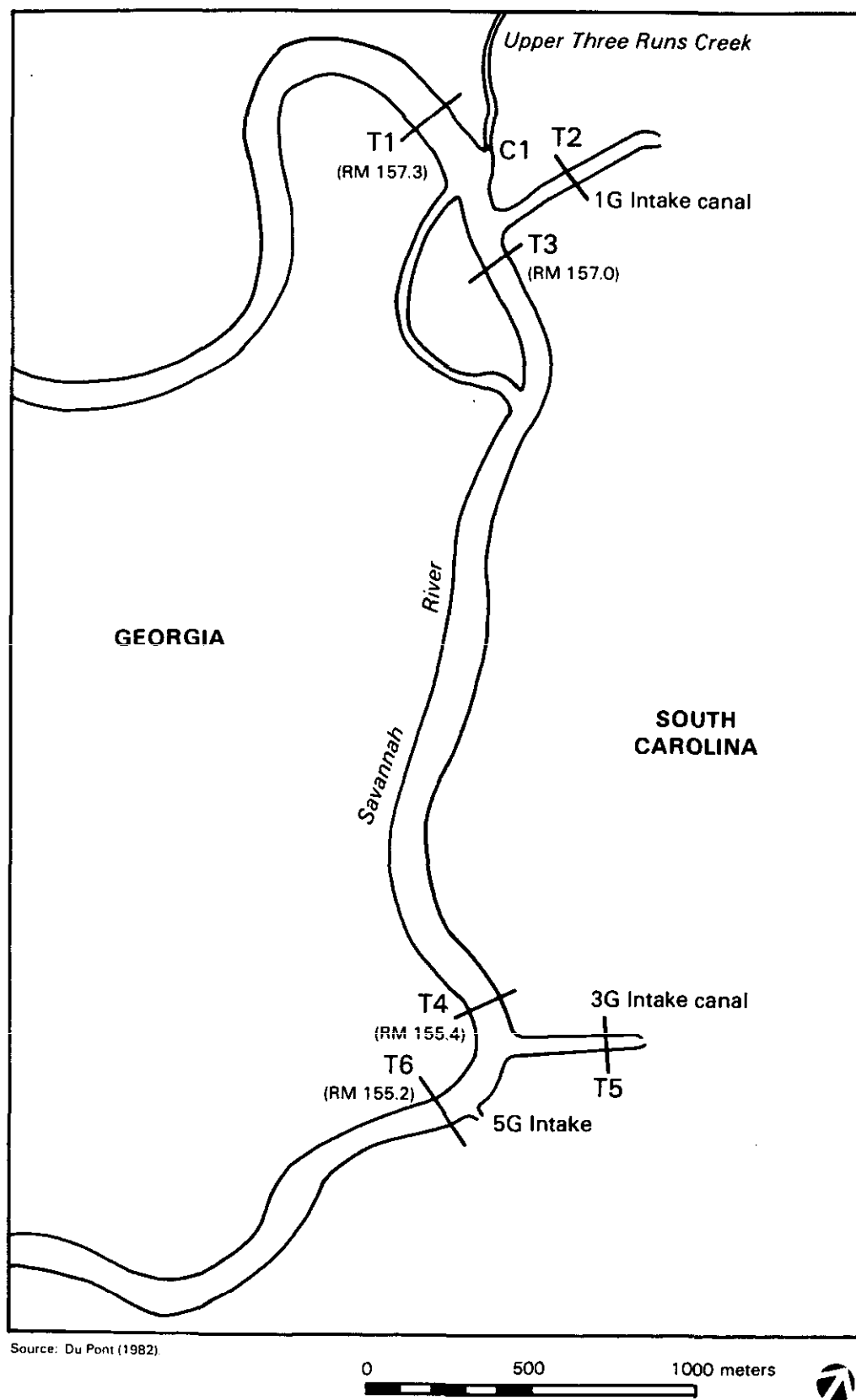
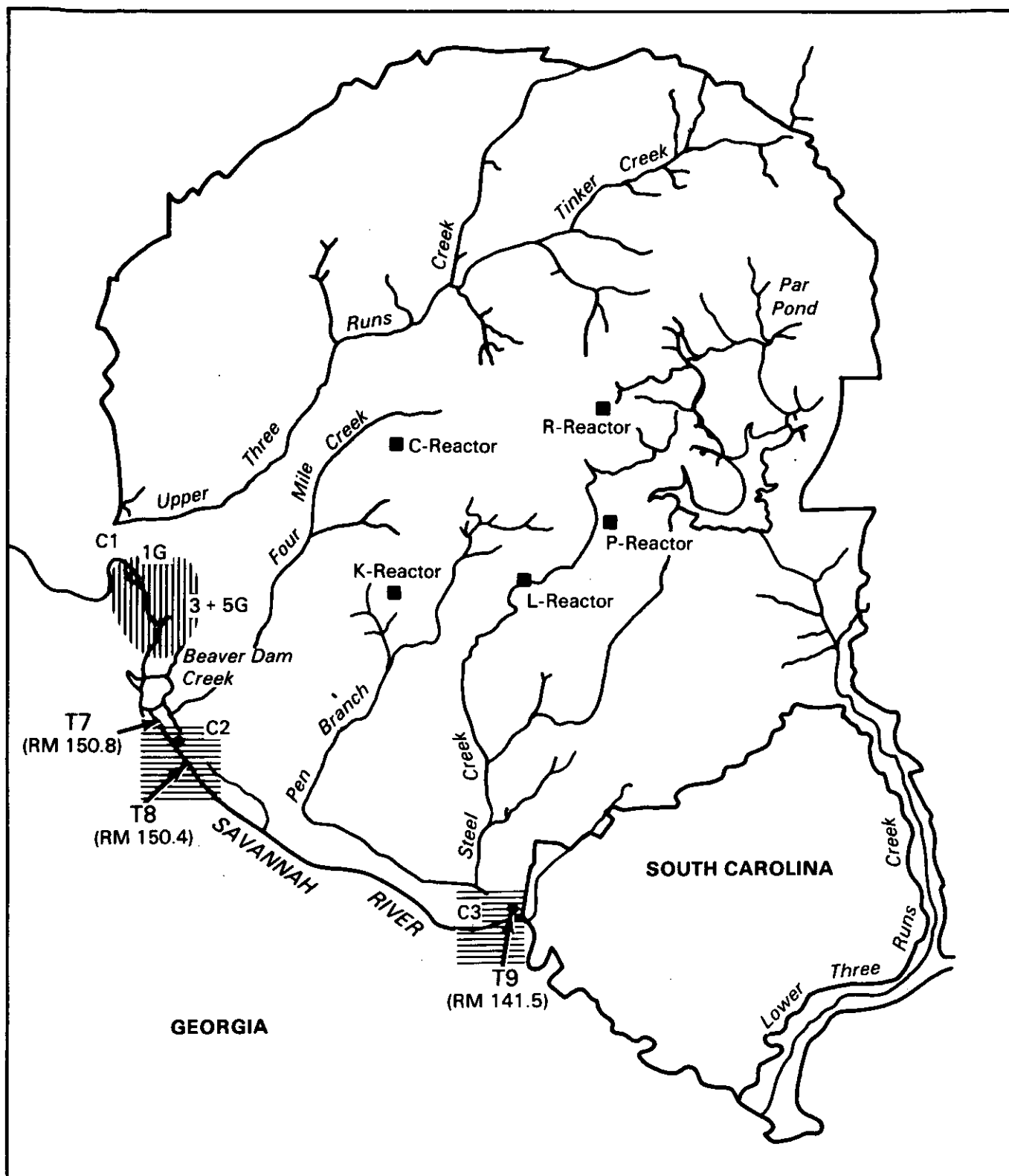


Figure C-12. Location of sampling transects T1 through T6 and station C1.



Legend:



Intake study areas



Thermal study areas

0 2 4 6 8 10 kilometers



Source: Du Pont (1982)

Figure C-13. Location of sampling transects T7 through T9 and stations C1, C2 and C3.

Table C-12. Number and relative abundance of larval fish collected at all stations in the Savannah River, March-August 1982^a and February-July 1983^b

Group	Total number collected		Percentage composition	
	1982	1983	1982	1983
Unidentified clupeids	1740	2957	33.6	6.9
Unidentified minnows	980	5557	18.9	13.0
Spotted sucker	825	1913	15.9	4.5
<u>Dorosoma</u> spp.	482	8234	9.3	19.3
Sunfish and bass	294	1778	5.7	4.2
Yellow perch	206	1658	4.0	3.9
Blueback herring	127	5648	2.5	13.2
American shad	110	653	2.1	1.5
Other	89	723	1.7	1.7
Unidentified suckers	88	321	1.7	0.8
Darter	88	1035	1.7	2.4
Carp	52	1370	1.0	3.2
Pirate perch	48	3105	0.9	7.3
Unidentified catfish	21	27	0.4	0.1
Sturgeon	15	10	0.3	<0.1
Gar	6	9	0.1	<0.1
Atlantic needlefish	4	6	0.1	<0.1
Swamp fish	1	7	<0.1	<0.1
Crappie		7257		17.0
Mud minnow		6		<0.1
Mosquito fish		4		<0.1
Pickrel		129		0.3
Silverside		160		0.4
Striped bass		88		0.2
Total	5176	42,655	100.0	100.0

^aAdapted from ECS, 1982.

^bAdapted from ECS, 1983d, which includes only daytime samples.

Table C-13. Number and relative abundance of eggs of each fish group collected in the Savannah River, March-August 1982^a and February-July 1983^b

Group	Total number collected		Percentage composition	
	1982	1983	1982	1983
Clupeidae				
American shad	3550	3612	70.6	50.7
Blueback herring	380	417	7.5	5.9
Percidae				
Perch and darters	87	309	1.7	4.3
Percichthyidae				
Striped bass	494	852	9.8	12.0
Other	<u>518</u>	<u>1928</u>	<u>10.4</u>	<u>27.1</u>
Total	5029	7118	100.0	100.0

^aAdapted from from ECS (1982).

^bAdapted from ECS (1983d), which includes only daytime samples.

AY-2,
EZ-1,
EZ-5

Fish larvae were generally distributed uniformly at the river stations and were dominated by shad, herring, and spotted sucker larvae (Table C-13). Fish eggs tended to be more concentrated in the middle portion of the river and often near the bottom. The intake canals had high densities of larvae and low densities of eggs. The eggs entrained into the canals probably settled to the bottom because of low-flow rates in the canal. Steel Creek and Upper Three Runs Creek contained numerous larvae and were sites for blueback herring spawning. High temperatures in Four Mile Creek precluded any extensive spawning in these waters.

Peak spawning activity occurred in May 1982. In May and June the abundance of fish eggs and larvae was significantly higher in nighttime collections than in daytime collections. Fourteen sturgeon larvae were also collected in 1982; both the Atlantic and shortnose sturgeon were represented (Table C-14).

A total of 26 transects in the river and 2 in the SRP intake canals were sampled weekly from February 1 through July 31, 1983. The river transects were located between River Miles 187.1 and 29.6. The 1G and 3G intake canals are located at about River Miles 157.0 and 155.4, respectively. These stations were divided into three groups for the analysis of the results:

Lower Farfield (downstream from SRP): River Miles 29.6 to 120.0 (ten stations)

Nearfield (adjacent to SRP): River Miles 128.9 to 157.3 (13 river stations plus the two intake canal stations)

AY-2,
EZ-1,
EZ-5

Table C-14. Locations and dates where sturgeon larvae were collected in the Savannah River during 1982 and 1983^a

Date of collection	River Mile	Species
3/12/82	157.3	Shortnose sturgeon
3/26/82	157.3	Shortnose sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	155.2	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
4/22/82	150.8	Atlantic sturgeon
4/22/82	157.0	Atlantic sturgeon
5/21/82	155.4	Atlantic sturgeon
5/21/82	155.4	Atlantic sturgeon
5/21/82	157.0	Atlantic sturgeon
5/21/82	157.3	Atlantic sturgeon
8/12/82	157.3	Atlantic sturgeon
3/09/83	79.9	Shortnose sturgeon
3/22/83	155.4	Shortnose sturgeon
3/22/83	157.1	Shortnose sturgeon
3/22/83	155.3	Shortnose sturgeon
3/22/83	155.2	Shortnose sturgeon
3/23/83	97.5	Shortnose sturgeon
3/29/83	155.2	Shortnose sturgeon
4/26/83	129.1	Atlantic sturgeon
5/03/83	157.0	Atlantic sturgeon
5/10/83	155.4	Atlantic sturgeon
5/17/83	150.4	Atlantic sturgeon
5/18/83	69.9	Atlantic sturgeon
6/14/83	150.8	Atlantic sturgeon

^aAdapted from Matthews and Muska (1983). These include all sturgeon taken during day and night sampling.

Upper Farfield (upstream of SRP): River Miles 166.6 to 187.1 (three stations)

A total of 36,941 fish larvae and 6308 fish eggs were collected during this period. The most abundant taxa were the Clupeidae, a family that contains the anadromous species blueback herring and American shad, as well as the forage species Dorosoma sp. Crappie and minnow larvae were also abundant (Table C-12).

In general, during February, March, and April, densities of total ichthyo-plankton (eggs and larvae combined) were highest in the lower reaches of the river and decreased in an upstream direction. May was a transitional month when densities were more uniform throughout the river. During June and July, densities were generally higher in the nearfield and upper farfield than in the areas downstream. The trend of generally higher densities nearer the river mouth

earlier in the year is largely because the lower Savannah River warmed more rapidly than the upper reaches and provided suitable spawning conditions for a longer period of time. However, such factors as the migratory movement of spawning adults might also play a role in these trends.

The seasonal pattern observed was the same throughout the stretches of river sampled: low densities occurred in February, increased to peak values in May, and declined to low levels in July.

The eggs and larvae of the American shad were collected in all three river areas. A total of 3557 eggs and 512 larvae of this species were taken. Highest densities were observed during May at River Mile 157.3. Mean densities for the 6-month collection period were higher above River Mile 89.3 than below. Thus, the region of maximum spawning of this species in 1983 included, but was not limited to, the SRP area.

Blueback herring eggs and larvae were also collected in all three river areas. The highest densities were observed in April at River Mile 97.5. During all months, densities of this species were greater in the lower farfield than in the nearfield and upper farfield areas.

A total of 852 striped bass eggs and 88 larvae was collected during the 1983 river study. Striped bass ichthyoplankton were prevalent only in May and June, although a few were found in April. During May, eggs and/or larvae were collected at all 10 lower farfield transects; at 10 of the 15 nearfield transects, the greatest densities occurring between River Miles 155.4 and 152.0; and at one of three upper farfield transects. During June, ichthyoplankton of this species was collected at only eight transects overall. Densities were highest at River Miles 129.1 and 166.6. Striped bass were found at only two transects in April, both in the nearfield area. Based on these results, it appears that the entire length of the Savannah River that was sampled (from River Mile 29.6 to River Mile 166.6) was used by the striped bass for spawning in 1983.

Yellow perch larvae were collected in all three of the river areas sampled. Highest densities were observed in April between River Miles 97.5 and 141.7. Densities were also high in this area during other months. This maximum-density region included the section of river below and, in April, slightly above Steel Creek, which is a major producer of yellow perch ichthyoplankton.

Crappie were the second most numerous larvae in the collections; a total of 6126 were identified. No eggs of this species were identified. Crappie reached greatest densities in March and April. They were most numerous in the lower farfield during both months. Densities were somewhat lower in May and much lower during all other months.

Minnows, which are important as forage for predatory species, were present during all months sampled. A total of 5170 larvae were found. This species first appeared in significant numbers during March. During this month, mean densities of larvae (no eggs were identified as minnow) were highest in the lower farfield but were also high in the nearfield between Lower Three Runs Creek and River Mile 141.7. Minnow densities were much higher in April, but the same basic pattern of higher densities downstream of River Mile 141.7 was evident. Densities peaked in May, especially in the nearfield.

AY-3 Ten sturgeon larvae were collected during the routine 1983 ichthyoplankton studies: four shortnose sturgeon (in March) and six Atlantic sturgeon (in April, May, and June). All were collected between River Miles 69.9 and 157.0. Three other shortnose sturgeon larvae were collected during other sampling in 1983 (Table C-14).

During several months, some fish taxa exhibited somewhat higher densities in the intake canals than in the adjacent river. In March and May, crappie ichthyoplankton densities were higher in the canals than the nearby river, as were blueback herring in April and Dorosoma sp. in June. These data suggest that crappie, blueback herring, and Dorosoma were spawning in the intake canals in 1983. However, all three taxa exhibited comparable or higher densities elsewhere in the river, indicating that other locations were equally or more important as spawning sites.

Adult fish sampling stations for the 1982 studies were the same as those described for fish eggs and larvae. At the river stations, canal stations, and Upper Three Runs Creek, a 100-meter section of shoreline was measured and marked. On Four Mile Creek and Steel Creek, the lengths of the shocking transects were limited to less than 100 meters by fallen trees that blocked the creeks.

Electrofishing and hoopnet collections were made in each sample area on four occasions within a 12-day period in August and October 1982 and January 1983. The repeated sampling was conducted to obtain a more complete species list and to collect sufficient numbers of fishes for an estimate of their relative abundance. Most fish collected were returned alive to the river following analysis.

Over 2400 fishes in 55 species have been collected to date. The adult fish community was dominated by spotted sucker, bowfin, redbreast sunfish, catfish, and flat bullhead (Table C-15).

The numbers of fishes taken in the river station collections by both electrofishing and hoop netting were similar in August and October and more variable in January. Fishes congregated in the heated discharge areas in the colder months and were absent from them during warm months.

Intake canal collections generally contained smaller fishes than the river collections and were dominated by centrarchids.

Creek station collections differed markedly from each other. Steel Creek had the highest fish density in October while the heated Four Mile Creek had the highest density in January. Upper Three Runs Creek had fish densities similar to river stations.

These data were consistent with the results of electrofishing collections made by the Georgia Game and Fish Division (1982) in the Savannah River. The Georgia study listed redbreast sunfish, striped mullet, spotted sucker, and bluegill as the most abundant fishes, exclusive of miscellaneous minnows. McFarlane et al. (1978a) listed redbreast sunfish, bluegill, and spotted sucker as the three most common species, exclusive of minnows.

Table C-15. Relative abundance of fishes collected by electrofishing in the Savannah River, August 1982, October 1982, and January 1983^a

Species	Percentage abundance		
	August 1982	October 1982	January 1983
Longnose gar	0.6	0.5	4.0
Bowfin	5.5	13.6	15.1
American eel	4.2	3.6	0.3
Blueback herring	0.0	2.4	0.0
American shad	3.9	0.0	0.0
Gizzard shad	2.9	1.9	4.5
Threadfin shad	0.0	0.0	2.3
Redfin pickerel	0.0	0.7	5.4
Chain pickerel	1.3	1.3	3.4
Carp	1.6	0.3	1.4
Golden shiner	0.0	0.0	0.3
Spotted sucker	15.3	13.5	22.7
Silver redhorse	1.3	0.9	1.4
Flat bullhead	1.0	0.0	0.3
Channel catfish	0.0	0.2	0.0
Pirate perch	0.0	0.9	0.0
Flier	0.0	0.0	0.9
Redbreast sunfish	18.8	22.4	7.1
Pumpkinseed	0.0	0.0	0.3
Warmouth	0.6	1.2	0.0
Bluegill	4.5	11.2	2.6
Dollar sunfish	0.0	1.4	0.0
Redear sunfish	15.0	3.3	7.7
Spotted sunfish	1.3	7.1	4.8
Largemouth bass	7.1	7.9	8.5
White crappie	0.0	0.7	0.3
Black crappie	0.6	0.7	3.7
Striped mullet	11.7	1.5	1.1
Yellow perch	2.3	2.0	2.0
Hogchoker	0.6	0.8	0.0

^aAdapted from ECS (1983b,c).

The Savannah River fisheries program was expanded in February 1983 to collect samples of fish eggs and larvae from the river and its major tributaries from Augusta to near Savannah. The results of the river portion of the study are given above. The information obtained from the sampling of the tributary creeks is given below.

A total of 27 creeks were sampled for ichthyoplankton from 5 to 23 times during the February through-July 1983 period. Five of these creeks drain portions of SRP: Beaver Dam Creek, Upper and Lower Three Runs Creeks, Four-Mile Creek, and Steel Creek. The remainder lie upstream or downstream of the site.

AY-2,
EZ-1,
EZ-5

A total of 5714 fish larvae and 810 fish eggs were collected. Spirit Creek (River Mile 182.8) had the highest number of ichthyoplankton with 1530 eggs and larvae taken in 19 samples. The high number at this location was due to the unusually high number of eggs (primarily Dorosoma sp.) collected during May and June.

Steel Creek yielded 518 fish larvae and 103 eggs in 23 collections. The larvae were predominantly minnows, yellow perch, and sunfish and bass. Many blueback herring eggs were also collected. When compared to other creeks that were sampled ten or more times, Steel Creek ranked eighth in larval density of all species combined. This creek was distinctive in having minnows and yellow perch represent about 27 and 30 percent, respectively, of the fish larvae collected. In all other streams of a similar size, these two species made up no more than about 13 and 7 percent of the total larvae, respectively. In Steel Creek, densities of crappie and larvae relative to other species were much lower than in the other large streams sampled.

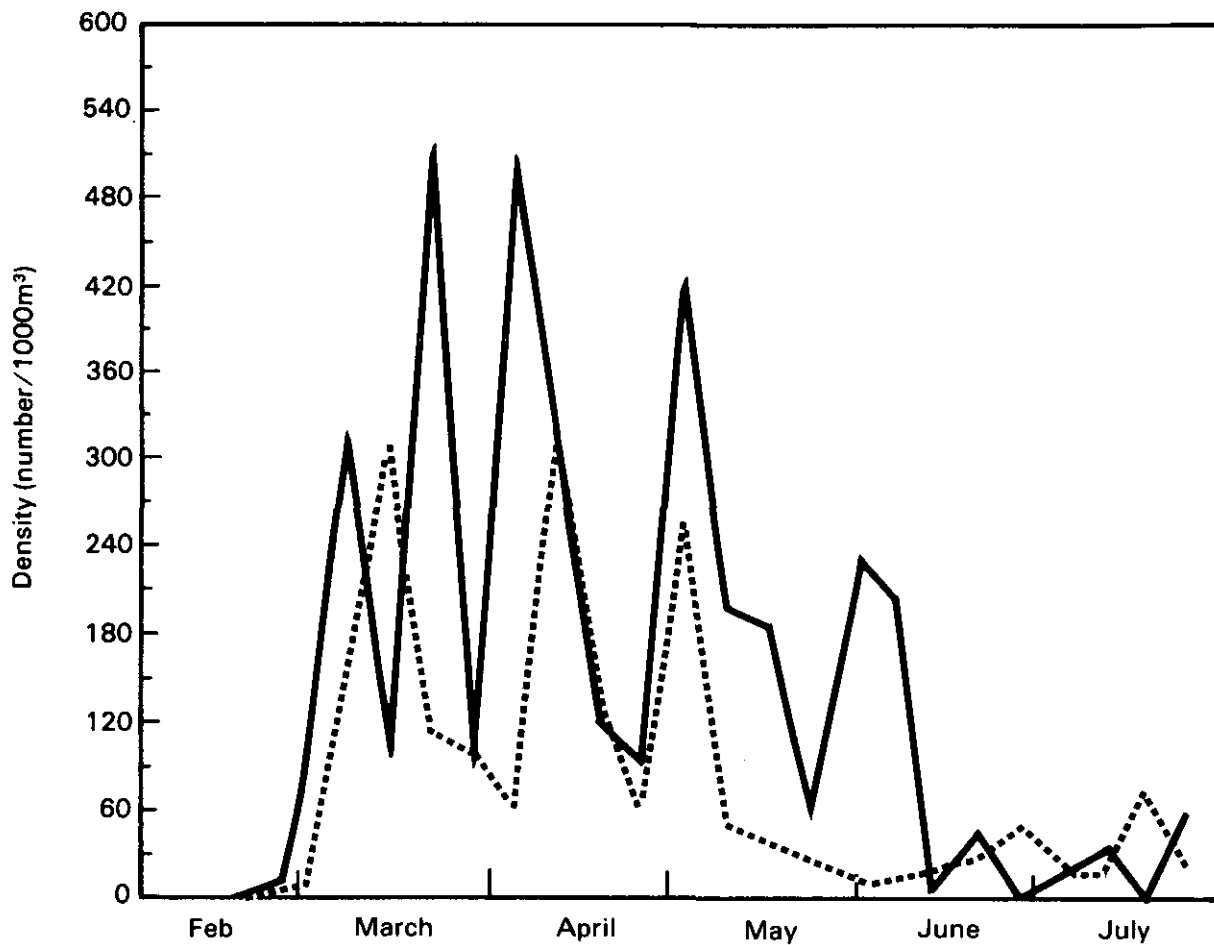
Seasonal trends in larval abundance in Steel Creek indicated peaks in density in March and April that were due to high numbers of yellow perch. Peaks in May and June were caused by sunfish and minnows. The maximum density occurred on May 3, 1983. This sample period coincided with a sharp reduction in river level; the high density probably reflects a large number of sunfish larvae in the water draining from the swamp.

Seasonal trends in larval density in Steel Creek were compared to seasonal trends in mean larval density at the six similar large creeks. Spawning peaks occurred both earlier and later in the season in Steel Creek than at the other locations. Larval density was generally higher than the mean of the other creeks.

There was much more fish spawning in Four Mile Creek in 1983 than in 1982, apparently because high river levels reversed stream flow sufficiently to allow fish to enter the creek. A high density of larvae, mostly of the blueback herring, was observed on April 4, 1983. However, similar medium-sized streams that were sampled had higher larval densities and longer spawning periods than Four Mile Creek. Apparently, the elevated water temperatures in this stream were a factor that limited spawning.

Beaver Dam Creek was sampled 13 times and larvae were collected on all but one date. The larvae were predominantly sunfish and silversides.

The seasonal trend of ichthyoplankton abundance in four select creeks (Ebenezer, Briar, Steel, and Spirit) was evaluated from weekly samples between February and May, 1983 (ECS, 1983d). Densities of ichthyoplankton were relatively constant in Steel Creek, whereas densities fluctuated markedly in the other creeks (Figure C-14). Blueback herring spawning was greatest in Briar Creek, with high densities occurring over a 4-week period. Steel Creek had a high density of blueback herring on one sampling date (Figure C-15). Yellow perch larval density was higher in Steel Creek than in any of the other three creeks (Figure C-16).



AY-2,
EZ-1,
EZ-5

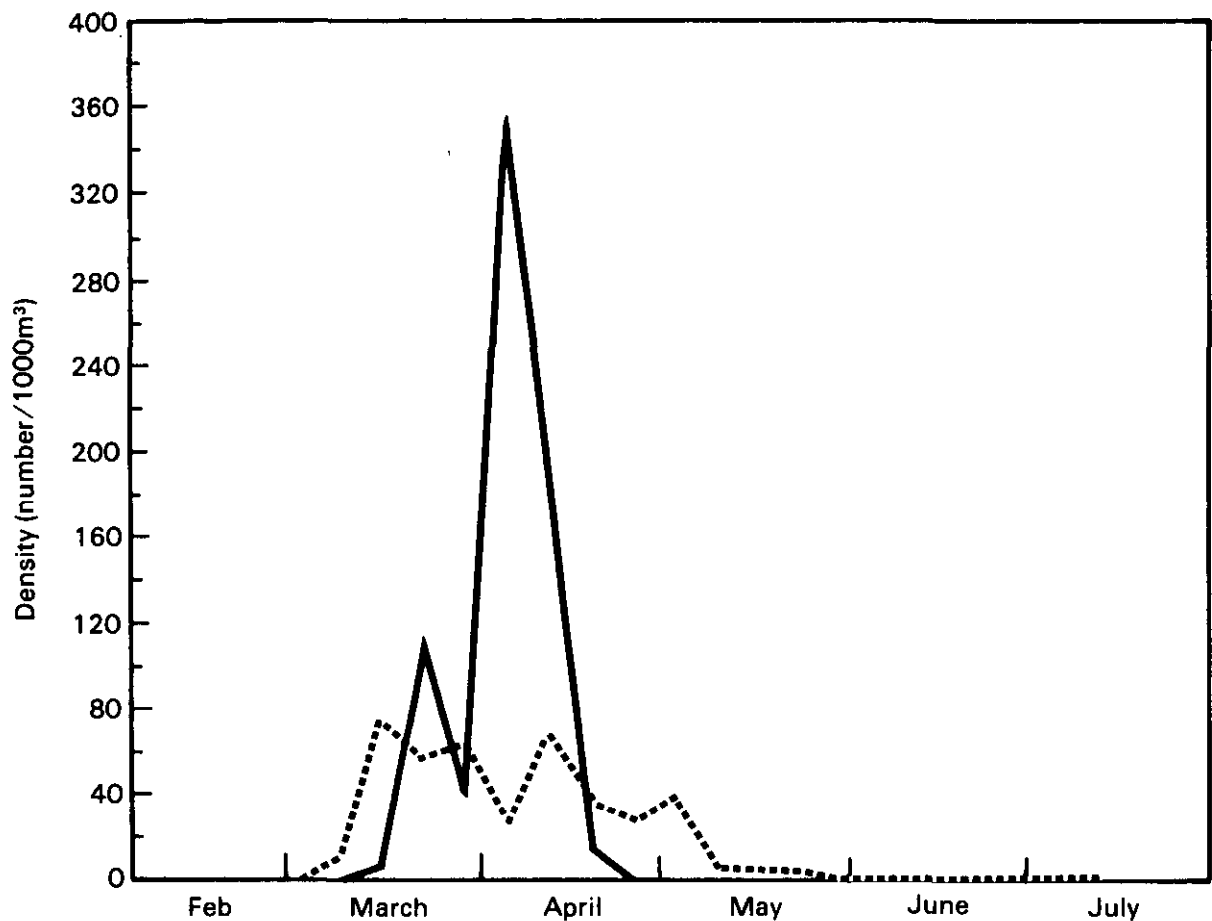
Legend:

— Steel Creek
 Average of other large creeks

Adapted from ECS (1983d). Other large creeks include: Smith Lake (Rm 126.5), Briar (Rm 97.6), Ebenezer (Rm 44.8), Coleman Lake (Rm 40.3), Meyer's Lake (Rm 35.4) and Collins Creeks (Rm 30.0).

Figure C-14. Average density of ichthyoplankton (eggs and larvae combined) for Steel Creek and all other large creeks, February-August, 1983.

AY-2,
EZ-1,
EZ-5



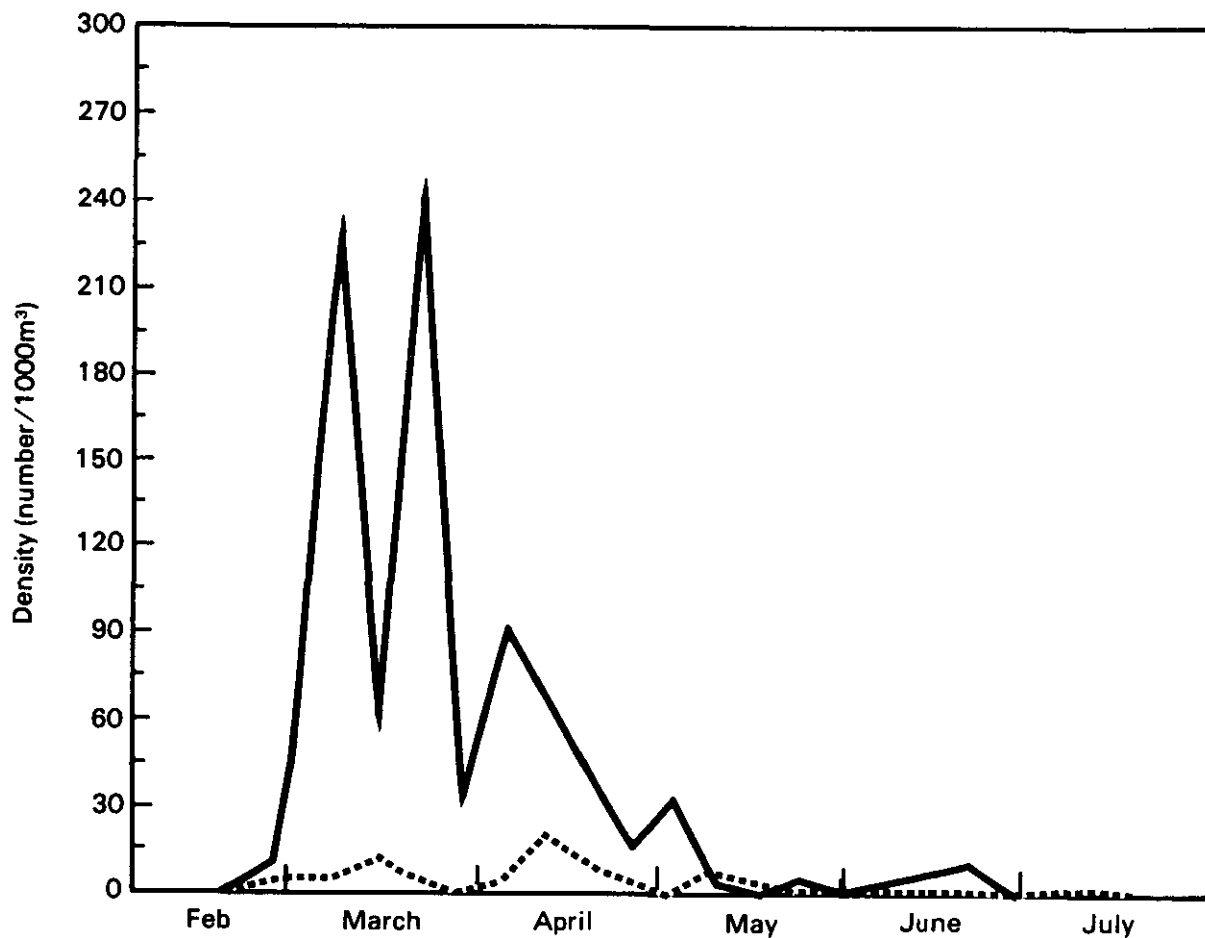
Legend:

— Steel Creek

..... Average of other large creeks

Adapted from ECS (1983d). Other large creeks include: Smith Lake (Rm 126.5), Briar (Rm 97.6), Ebenezer (Rm 44.8), Coleman Lake (Rm 40.3), Meyer's Lake (Rm 35.4) and Collins Creeks (Rm 30.0).

Figure C-15. Average density of blueback herring ichthyoplankton (eggs and larvae combined) for Steel Creek and all other large creeks, February-August, 1983.



AY-2,
EZ-1,
EZ-5

Legend:

— Steel Creek

..... Average of other large creeks

Adapted from ECS (1983d). Other large creeks include: Smith Lake (Rm 126.5), Briar (Rm 97.6), Ebenezer (Rm 44.8), Coleman Lake (Rm 40.3), Meyer's Lake (Rm 35.4) and Collins Creeks (Rm 30.0).

Figure C-16. Average density of yellow perch ichthyoplankton (eggs and larvae combined) for Steel Creek and all other large creeks, February–August, 1983.

Steel Creek fisheries program

The purpose of the 1982-1983 fish population studies in Steel Creek was to determine the use of the Steel Creek swamp and delta area by fishes and to characterize the fish community in terms of species use and relative abundance. Although some species known to occur within the Savannah River drainage are on the Federal or state lists of threatened and endangered species, no such fish have been collected in Steel Creek. Fish listed among South Carolina's commercially and recreationally important species have been collected. The commercially important species are primarily anadromous.

The Steel Creek area of the Savannah River swamp was divided into six sampling areas (Figure C-17) to determine habitat utilization by resident and anadromous fish (Smith et al., 1982a,b, 1983). The lower Steel Creek channel between the swamp and the Savannah River was also sampled. Sampling for anadromous fish began on January 30, 1982, and continued through 1983.

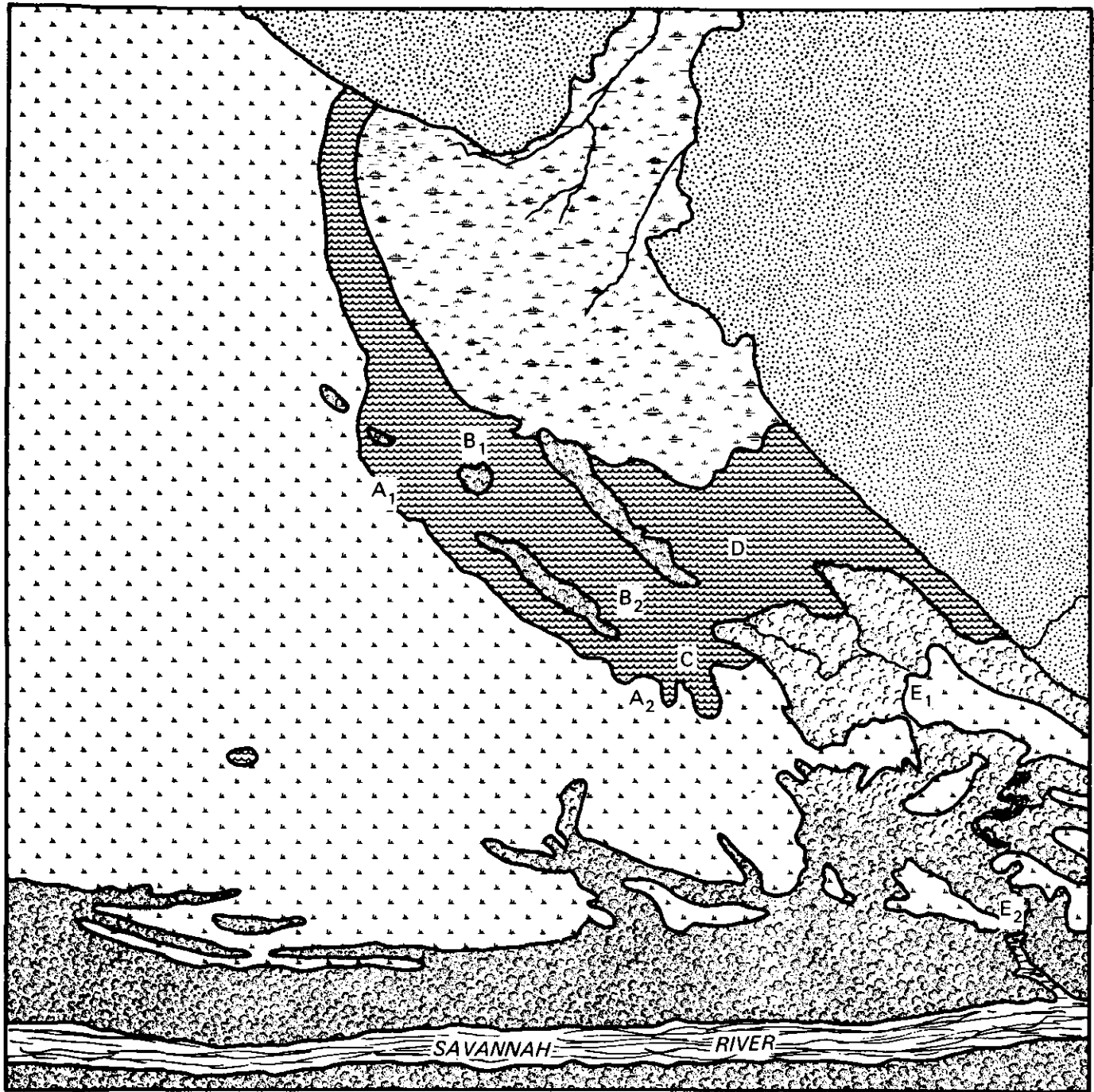
Fish of various sizes were collected for most species. The collections should be representative of both relative abundance and species composition of the swamp fish community. A total of 5313 fish representing 55 species were collected from the Steel Creek-river-swamp system from November 1981 through July 1982. A total of 1000 individuals representing 31 species was collected by fyke nets in Steel Creek from February through May of 1983 (Smith et al., 1982b) (Table C-16).

Figure C-18 shows the mean number of fish collected per 50-meter transect in the Steel Creek swamp area. The order of rankings of mean number of fish collected in each area were $B_1 > A_1 > B_2 > C > A_2$, with more fish collected in Area B_1 than in all other areas.

Areas B_1 and B_2 also appear to be important as spawning and/or nursery areas for resident fishes in the swamp. Young-of-year fishes were captured almost exclusively in these areas, although no spawning activity was ever observed. Young-of-year fish dispersed into other areas as they increased in size through the summer.

No major run of anadromous fish was detected in the Steel Creek area during 1982; a total of six American shad and four blueback herring was collected with fyke nets from February through April. To determine if the nets were an effective method for capturing clupeids, portions of lower Steel Creek were electro-fished on selected dates; few fish were collected. Conversations with fishermen at the confluence of Steel Creek and the Savannah River also suggested that a major run did not occur in 1982 and that this year was atypical (Smith et al., 1982a). There was greater utilization of the Steel Creek delta-swamp area by adult shad and blueback herring in 1983 when compared to 1982 (76 shad in 1983 versus 6 in 1982; 124 blueback herring in 1983 versus 4 in 1982). Two striped bass were collected in this area in 1983 while none were collected in 1982 (Smith et al., 1983).

The 1982-1983 sampling provided information on which areas of the Steel Creek system are used by these species. The majority of fish were collected in lower Steel Creek channel with some fish being collected from the fast water



Legend:



Upland



Bottomland hardwoods



Steel Creek Delta



Cypress-Tupelo Swamp



Permanently flooded

A₁, A₂, etc., represent sampling locations

0 300 600 meters



Source: Smith, Sharitz, and Gladden (1983).

TC

Figure C-17. Fish sampling locations in the Steel Creek delta and swamp, 1981-1983.

Table C-16. Total number of fish (by species) collected with fyke nets in Steel Creek and Upper Three Runs Creek, February-May 1983^a

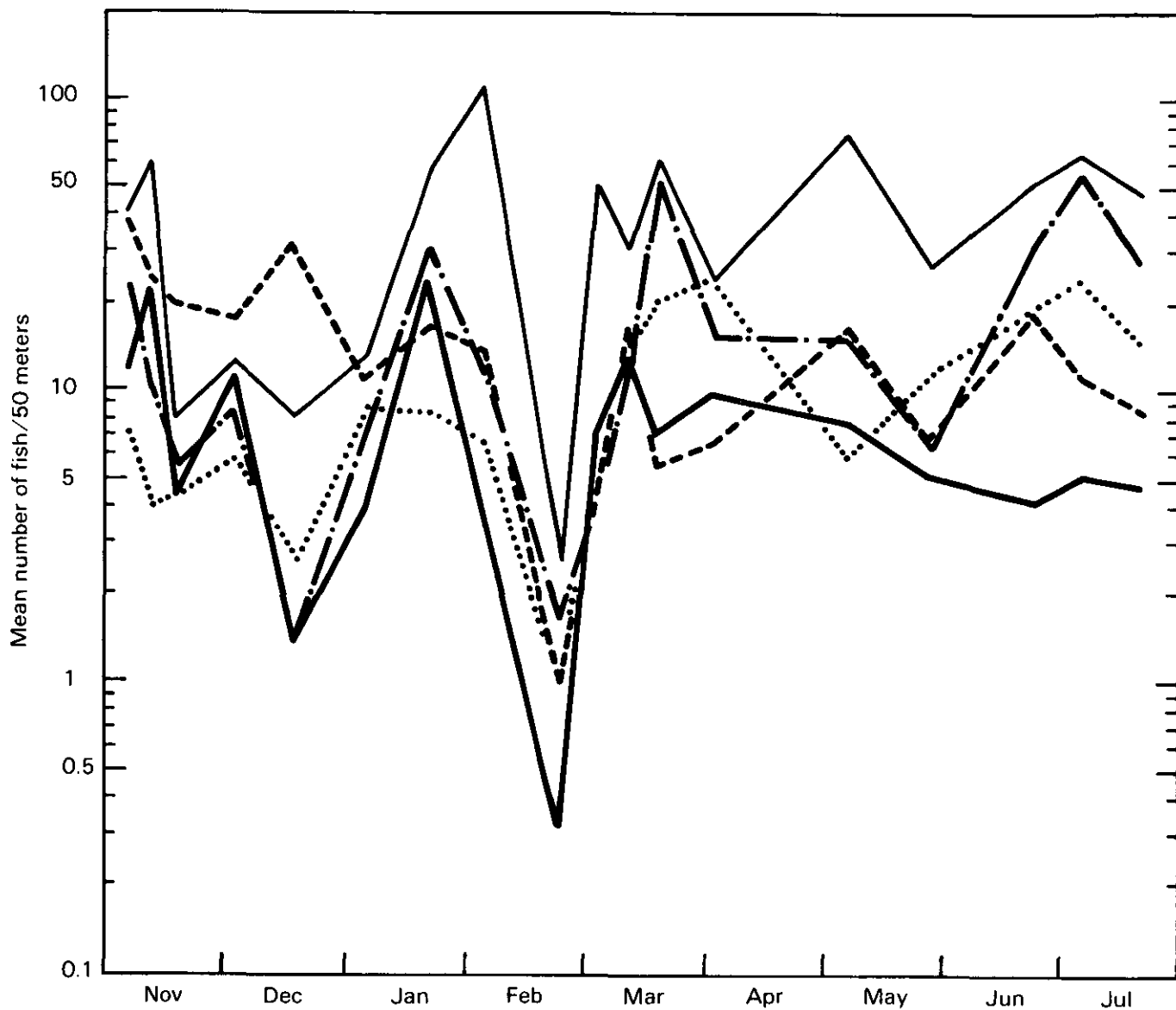
Species	Steel Creek		Upper Three Runs Creek
	Upper net	Lower net	
Bowfin	14	11	9
American eel	2	2	8
Atlantic needlefish	0	1	0
Lake chubsucker	2	0	0
Spotted sucker	8	3	4
Flier	0	4	25
Redbreast sunfish	0	2	6
Warmouth	0	0	1
Bluegill	1	0	9
Redear sunfish	0	2	3
Spotted sunfish	12	0	0
Largemouth bass	1	0	0
Black crappie	4	3	14
Hickory shad	21	10	20
American shad	35	41	5
Blueback herring	48	76	209
Gizzard shad	74	64	97
Carp	0	1	0
Golden shiner	1	3	5
Chain pickerel	1	0	1
White catfish	3	0	5
Yellow bullhead	6	0	0
Brown bullhead	4	1	0
Flat bullhead	4	3	2
Channel catfish	34	6	15
Unidentified Ictalurid	1	0	0
Longnose gar	223	319	228
Florida gar	12	23	49
Striped mullet	6	7	1
Striped bass	1	1	2
Striped bass (hybrid)	0	0	4
Total	518	583	722

^aAdapted from Smith et al. (1983).

areas of the swamp. Other migratory fish that were collected included the Atlantic needlefish and striped mullet.

C.5 ENDANGERED AND THREATENED SPECIES

The Endangered Species Act of 1973 (Public Law 93-205) is administered by the U.S. Fish and Wildlife Service in conjunction with cooperating states and



Legend:

- Area A₁
- Area A₂
- Area B₁
- . - Area B₂
- Area C

Source: Smith et al. (1983).

Figure C-18. Mean number of fish per 50-meter transect, collected in areas of the Steel Creek swamp, November 1981-July 1982.

other Federal agencies, and affords protection to some 300 species of native American plants and animals. A species can be federally listed under either of two categories, endangered or threatened, depending on its status and the degree of the threat posed to it. Endangered refers to a species or subspecies that is in danger of extinction throughout all or a significant portion of its range. Threatened means any species or subspecies that is likely to become endangered in the foreseeable future throughout all or a significant portion of its range. When a species is proposed for the endangered or threatened status, areas essential to its survival or conservation are also proposed as "critical habitat," when appropriate. Compliance with the Endangered Species Act requires Federal agencies to consult with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service on potential impacts and mitigation and to conduct a biological assessment of any listed or proposed species that might be present in the area of the proposed action.

In addition to the Federal list, the State of South Carolina also recognizes and affords protection to fauna in accordance with the South Carolina Non-game and Endangered Species Conservation Act of 1974. However, the State does not afford protection to flora other than federally protected species.

TC | The following section addresses those species that are protected by Federal and state law. These include 3 plants, 1 bivalve, 1 fish, 1 reptile, 11 birds, and 2 subspecies of mammals (Table C-17). Species with historic ranges that include the Savannah River Plant are mentioned briefly even though they are unlikely to occur in the impact area. Where possible, emphasis is given to the vicinity of L-Reactor, Steel Creek and its delta, and the Savannah River. (For listings of unprotected taxa such as those of "special concern" or "peripheral," consult Forsythe and Ezell (1979) and Rayner et al. (1979).)

C.5.1 Flora

Two endangered and one proposed endangered species of vascular plants are listed by the U.S. Department of the Interior (USDOI, 1983) for South Carolina. None have been identified on the SRP site or near Steel Creek during field studies conducted over the past 25 years.

Termed the rarest orchid in America, the small whorled pogonia (Isotria medeoloides) is currently proposed by the Fish and Wildlife Service as an endangered species; only 16 populations, which include 150 to 175 individual plants, are estimated to exist within its phytogeographical range, which extends from Canada to Georgia (Norkin, 1980). The only population known to exist in South Carolina is in the Sumter National Forest, where its habitat includes second-growth deciduous or deciduous/coniferous forests having an open canopy, sparse shrub and herbaceous layers, and proximity to streams, roads, or rights-of-way.

The persistent trillium (Trillium persistens), a member of the lily family, is known only from a 6.5-kilometer area of northern Georgia and South Carolina (Finnley, 1979a). Its preferred habitat consists of hemlock-dominated or yellow-poplar-dominated cove forests with an understory of great laurel (Rhododendron maxima) of varying density. The occurrence of this plant anywhere on the SRP site is doubtful (Rayner, personal communication with G. P. Friday).

Table C-17. Endangered and threatened species inhabiting or potentially occurring on Savannah River Plant site

Common name	Scientific name	Status	Listing agency ^a	Critical habitat designation	Occurrence on SRP ^b	Preferred habitat
Arrowhead, bunched	<u>Sagittaria fasciculata</u>	Endangered	USDI	No	Unknown	Swamps and bogs (Radford et al., 1964); hemlock- or yellow-poplar-dominated coves having an understory of great laurel (Rayner et al., 1979)
Persistent trillium	<u>Trillium persistens</u>	Endangered	USDI	No	Unknown	
Small-whorled pogonia	<u>Isotria medeoloides</u>	Endangered (proposed)	USDI	No	Unknown	Wooded slopes and along streams (Radford et al., 1964); deciduous/coniferous forest having an open canopy, open shrub layer, and sparse herbaceous layer
Brother spike mussel	<u>Ellipio fraterna</u>	Endangered	SC	No	Unknown	Sandy, freshwater shallows; collected in 1972 near SRP (Fuller, 1979)
Shortnose sturgeon	<u>Acipenser brevirostrum</u>	Endangered	USDI	No	Unknown	Historically, spawns in rivers from New Brunswick to Florida (Forsythe and Ezell, 1979)
American alligator	<u>Alligator mississippiensis</u>	Endangered	USDI, SC	No	Confirmed	Swamps, creeks, impoundments, or other wetland areas
Cooper's hawk	<u>Accipiter cooperii</u>	Threatened	SC	No	Confirmed	Open woodlands and wood margins (Robbins et al., 1966); a probable resident on SRP (Du Pont, 1982)
Golden eagle	<u>Aquila chrysaetos</u>	Endangered	SC	No	Unknown	Mountains, grasslands, remote areas; winter range includes SRP (Robbins et al., 1976)

Table C-17. Endangered and threatened species inhabiting or potentially occurring on Savannah River Plant site (continued)

Common name	Scientific name	Status	Listing agency ^a	Critical habitat designation	Occurrence on SRP ^b	Preferred habitat
Ivory-billed woodpecker	<u>Campephilus principalis</u>	Endangered	USDI, SC	No	Unknown; probably extinct (Gauthreaux et al., 1979)	Undisturbed, mature hardwood forest
Kirtland's warbler	<u>Dendroica kirtlandii</u>	Endangered	USDI, SC	No	Unknown	Jackpine in Michigan (nesting); winters in the Bahamas (Robbins et al., 1966); perhaps an infrequent transient in South Carolina
Swallow-tailed kite	<u>Elanoides forficatus</u>	Endangered	SC	No	Unknown	Swamps, marshes, river banks, and open forests (Robbins et al., 1966); breeds in swamplands of South Carolina's coastal plain (Forsythe and Ezell, 1979)
American peregrine falcon	<u>Falco peregrinus anatum</u>	Endangered	USDI, SC	California	Unknown	Coasts, mountains, and woods (Robbins et al.; 1966); regularly reported in South Carolina during migration and winter (Gauthreaux et al., 1979)
Bald eagle	<u>Haliaeetus leucocephalus</u>	Endangered	USDI, SC	No	Confirmed	Wooded or mountainous areas near water, including swamps and bottomlands; winters and breeds in South Carolina (Forsythe and Ezell, 1979)
Wood stork (ibis)	<u>Mycteria americana</u>	Endangered	USDI, SC	No	Confirmed	Swamps, marshes, and ponds (Robbins et al., 1966)

Table C-17. Endangered and threatened species inhabiting or potentially occurring on Savannah River Plant site (continued)

Common name	Scientific name	Status	Listing agency ^a	Critical habitat designation	Occurrence on SRP ^b	Preferred habitat
Osprey	<u>Pandion haliaetus</u>	Threatened	SC	No	Confirmed	Near fresh- or saltwater; may be seen in spring or fall but doesn't breed or winter in South Carolina (Robbins et al., 1966); an occasional migrant on SRP (Du Pont, 1982)
Red-cockaded woodpecker	<u>Picoides borealis</u>	Endangered	USDI, SC	No	Confirmed	Open, mature (averaging 75 years) pine forests having sparse ground cover (Finnley, 1979b)
Backman's warbler	<u>Vermivora bachmanii</u>	Endangered	USDI, SC	No	Unknown	Moist, deciduous woodlands (Robbins et al., 1966)
Eastern cougar	<u>Felis concolor cougar</u>	Endangered	USDI, SC	No	Unconfirmed	Isolated and remote areas, especially near swamps of the larger rivers (Golley, 1966)
Florida panther	<u>Felis concolor coryi</u>	Endangered		No	Unconfirmed	

^aKey: USDI = U.S. Department of the Interior; SC = South Carolina.

^bSavannah River Plant.

Only two populations of the endangered bunched arrowhead (Sagittaria fasciculata) have been confirmed--one in Henderson County, North Carolina, and the second in Greenville County, South Carolina. The latter population occupies a transmission line right-of-way along the headwaters of a river (Finnley, 1979a). The habitat of this plant is somewhat unique and consists of nearly level seepage areas that have a year-round, continuous supply of gently flowing cold water. The existence of this species on or near Savannah River Plant is very doubtful.

C.5.2 Fauna

C.5.2.1 Mussels

TC | Listed as endangered by the State, the brother spike mussel (Ellipio fraterna) has been identified only in the Chattahoochee and Savannah Rivers from sandbars beneath 0.3 to 0.6 meter of water (Britton and Fuller, 1980). The 1972 discovery of this bivalve in the Savannah River approximately 15 river miles downstream from the mouth of Steel Creek was the first documented collection in 130 years. The distribution and ecology of this species, particularly in the Savannah River, are poorly understood.

C.5.2.2 Fish

AY-3 | The shortnose sturgeon (Acipenser brevirostrum) is listed by the Federal Government as an endangered species in the United States (USDOI, 1983). The species is found only on the east coast of North America in tidal rivers and estuaries. Prior to 1982, the shortnose sturgeon had not been reported in the middle reaches of the Savannah River in the vicinity of the Savannah River Plant. However, shortnose sturgeon larvae were found in ichthyoplankton samples collected in the Savannah River above Upper Three Runs Creek and 3G pumphouse intake canal as part of the Savannah River Biological Measurement Program (ECS, 1983a). As a result, DOE initiated a consultation process with the National Marine Fisheries Service (NMFS) to comply with the Endangered Species Act of 1973 (ESA, Public Law 93-205, as amended). Based on the results of this consultation process, the NMFS concurred in DOE's determination that the population of the shortnose sturgeon in the Savannah River would not be adversely affected (Oravetz, 1983).

C.5.2.3 Amphibians

TC | No amphibians inhabiting the SRP are currently listed as endangered or threatened.

C.5.2.4 Reptiles

Listed as endangered by USDOJ (1983) and by the State, the American alligator (Alligator mississippiensis) is locally common on the Savannah River Plant; it breeds in Par Pond and the Savannah River swamp (Gibbons and Patterson, 1978). The ecology of this species has been examined intensively on the Savannah River Plant, and is presented in Section C.3.1.

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). In a biological opinion, FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially impacted by L-Reactor restart. Protection of these lagoons has been completed.

AB-4

Because of the delayed restart schedule for L-Reactor, the Fish and Wildlife Service requested reconsultation. DOE has subsequently reinitiated the consultation process, and has transmitted the most recent information and impact projections for this species (Sires, 1983, 1984a). DOE is awaiting a decision on its conclusion that the impacts resulting from the delayed restart of L-Reactor will not jeopardize the continued existence of the species.

C.5.2.5 Birds

The Cooper's hawk (Accipiter cooperii) is listed as threatened by the State, and has been documented on the Savannah River Plant during Christmas bird counts (Angerman, 1979, 1980).

The winter range of the golden eagle (Aquila chrysaetos), an endangered raptor of South Carolina, includes Savannah River Plant. The number of breeding birds in the mountains of the eastern United States has declined significantly recently, but management efforts should enhance its survival (Forsythe and Ezell, 1979). Its presence on the SRP site has not been confirmed, but it might overwinter in the Savannah River swamp.

According to the most recent information, the ivory-billed woodpecker (Campephilus principalis) is probably extinct (Gauthreaux et al., 1979). There have been no confirmed reports of this large woodpecker on the SRP site and it is extremely unlikely that it exists. Its preferred habitat is dense, isolated mesic or swamp hardwood forests.

The endangered Kirtland's warbler (Dendroica kirtlandii) is apparently very habitat-specific, and has never been found to nest anywhere except in northern lower Michigan; specifically, it nests among dense stands of young jack pine on Grayling sand (Senecal, 1981). It winters in the Bahama islands and could possibly occur on the SRP site as a transient, although its presence has never been confirmed.

The summer or breeding range of the swallow-tailed kite (Elanoides forficatus), an endangered hawk of South Carolina, includes Savannah River Plant,

but its presence has never been confirmed. Its preferred habitat includes swamps, marshes, river banks, and open forests (Robbins et al., 1966).

The endangered peregrine falcon (Falco peregrinus) has been extirpated as a naturally occurring breeding bird in the eastern United States. Since the 1950s, captive breeding of peregrines and subsequent releases by Cornell University have spearheaded recent management efforts to reestablish this raptor (Finnley, 1979c). This species is reported regularly during migration and winter in South Carolina (Gauthreaux et al., 1979), but it has not been reported on the Savannah River Plant.

The bald eagle (Haliaeetus leucocephalus), an endangered species, has declined dramatically in number in recent years. During the 1980-1981 season, 20 active bald eagle nesting territories were observed in South Carolina (Kearney, 1981). The bald eagle has been observed over Par Pond (Patterson, 1981), but its presence near L-Reactor and Steel Creek is unknown.

TC | The wood stork (Mycteria americana) is designated as endangered by South Carolina and the Fish and Wildlife Service. As many as 386 individuals were observed in 1983 feeding in the Savannah River swamp of Savannah River Plant. This species is discussed in greater detail in Section C.3.2.

The osprey (Pandion haliaetus), which is listed as threatened by the State, has been observed on Savannah River Plant (Du Pont, 1982) but is considered an occasional migrant. It typically does not breed or winter in South Carolina (Robbins et al., 1966), but might use the swamp and riverine habitats on the Savannah River Plant briefly during migration.

TC | The endangered and nonmigratory red-cockaded woodpecker (Picoides borealis), first listed in 1970, is estimated to number less than 10,000 individuals (Finnley, 1979b). Also habitat-specific, this woodpecker nests in cavities in living upland pine trees averaging 75 years of age. The nearest colony to Steel Creek is approximately 0.8 kilometer from SRP Road A-19 (Du Pont, 1982). Because upland stands of mature conifers will not be affected by thermal discharge from L-Reactor, no indirect adverse impacts will occur to this species due to habitat degradation. The U.S. Fish and Wildlife Service has issued a biological opinion that the red-cockaded woodpecker will be unaffected by L-Area operations.

The endangered Bachman's warbler (Vermivora bachmanii), one of the rarest and least known of North American warblers, might be extinct. If the species still occurs in the United States, it probably is restricted to swamplands of South Carolina's coastal plain (Gauthreaux et al., 1979). Systematic surveys of the I'On Swamp, its last confirmed sighting, have been unsuccessful; its presence has never been recorded on the Savannah River Plant.

C.5.2.6 Mammals

Two subspecies of the cougar (Eastern cougar (Felis concolor cougar) and the Florida panther (Felis concolor coryi)) have historic ranges which include South Carolina. While the swamp bottomlands could provide habitat for

individuals of either subspecies, there is no indication that either the Eastern cougar or the Florida panther occurs at Savannah River Plant.

C.6 AREAS OF SPECIAL CONCERN

Areas of special concern include environments that are recognized by a government agency or the scientific community as having unique or exceptional value as natural resources. This category includes (1) wetlands, (2) critical wildlife habitat, (3) state and national forests, (4) state and national game management areas (i.e., sanctuary, reserve, refuge, or preserve), (5) prime agricultural land, (6) designated natural areas, and (7) wild and scenic rivers. Of the areas listed above, only wetlands will be impacted by the proposed action. A description of the wetlands is given in Section C.2, above.

C.7 COMMERCIALLY AND RECREATIONALLY VALUABLE BIOTA

The utilization of fish and wildlife resources in South Carolina for commercial or recreational purposes is regulated by the South Carolina Wildlife and Marine Resources Department. This agency designates game species and season's creel and bag limits, and essentially regulates the fish and wildlife resources throughout the State.

Although the ecosystems of the Savannah River Plant support many populations of game and fish, commercial exploitation is prohibited and recreational use is restricted to controlled hunts of the white-tailed deer and feral hog. Despite restricted public access, poaching has been reported near the site's boundary and in the Savannah River swamp.

Commercially valuable plant biota on the Savannah River Plant include approximately 175,000 acres of timber that are managed by the U.S. Forest Service. The commercial value of timber on the Savannah River Plant that was managed and sold by the Forest Service was 1.7 million dollars in 1982; this included pine and hardwood sawtimber, pine pulpwood, and cordwood hardwoods. Approximately 71 percent of the timber sales consisted of pine pulpwood. The long-term trend in planting activities has been an increase in the number of loblolly pine and a decrease in slash pine. The latter is more susceptible to injury from ice glazing and has not been planted since 1970. Over 1,530,000 seedlings of loblolly pine and 160,000 seedlings of longleaf pine were planted in 1980 (USDA, 1983).

DY-1

Public hunting of deer and feral hogs on the SRP site has been managed by the Forest Service since 1966 to minimize deer-car accidents and to maintain habitat quality. Beginning in 1981, the planning and management responsibility of these hunts was given to E. I. du Pont de Nemours & Co.

The annual number of hunter-days increased from 700 in 1966 to 6325 in 1980; paralleling this trend was an increase from 198 deer killed in 1966 to 961 in 1980. The harvest of feral hogs ranged from 10 in 1972 to 32 in 1980. There also has been a relatively consistent decline in the number of deer-car

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accidents. In the late 1960s and early 1970s, deer-car accidents ranged in the 50s; only 11 incidents were reported in 1980.

Other game species that have commercial and recreational value but that are protected from hunting include the bobcat, fox, mink, muskrat, opossum, otter, rabbit, raccoon, skunk, squirrel, migratory waterfowl, bobwhite quail, mourning dove, wild turkey, Wilson's snipe, and woodcock.

The Savannah River supports both commercial and sports fisheries. Table C-18 lists the species and catches of fish taken commercially from the river from 1970 to 1979. Many of these fisheries are confined to the marine and brackish waters of the coastal regions of South Carolina and Georgia. Table C-19 lists the total weight of shellfish caught in the lower Savannah River and adjacent coastal waters between 1972 and 1979.

The only commercial fishes of significance near the Savannah River Plant are the American shad (Alosa sapidissima), the channel catfish (Ictalurus punctatus) and the Atlantic sturgeon (Acipenser oxyrinchus). These species, except for sturgeon, are exploited to a limited degree by nonprofessional local fishermen. There is no fishery specifically for hickory shad (Alosa mediocris) in South Carolina or Georgia; however, many are taken each year incidental to the catch of American shad (Ulrich et al., 1978).

Sport fishermen are the principal consumers of river fishes, primarily sunfish and crappie. Striped bass, which is classified as game fish in South Carolina and Georgia (Ulrich et al., 1978), is a favorite quarry of fishermen in the Augusta area.

Commercial and recreational fisheries for blueback herring (Alosa aestivalis) exist in South Carolina (Ulrich et al., 1978) but none are taken commercially in Georgia because of State netting restrictions.

Although species of commercial or sports importance in the Savannah River might use SRP streams, fishing or other exploitation of commercial species is not allowed on the site.

Anglers in the freshwater section of the Savannah River fish predominantly for bream and largemouth bass. Based upon electrofishing studies, the relative abundance of bream in the freshwater section of the river is high, as is the actual angler success rate. The lesser abundance of largemouth bass in the freshwater section results in a relatively low angler harvest of this species (Figure C-19).

Anglers in the estuarine section of the Savannah River fish predominantly for sea trout and striped bass. Electrofishing results indicate that these two species are not very abundant in the estuary. Actual angler success rates for these species are low (Figure C-20).

The Fisheries Section of the Georgia Department of Natural Resources recently published the results (Table C-20) of a fisheries study conducted on the Savannah River during the period July 1, 1981, to June 30, 1982 (Georgia Game and Fish Division, 1982). The study consisted of a creel survey of sports anglers and an electrofishing study. Together these studies provide data on the fish species most sought by anglers and on the probabilities of catching those species.

Table C-18. Commercial landing data for fish taken from Savannah River, 1970-1979^a

Species	Combined catches in Georgia and South Carolina (kg)									
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Carp	0	250	252	1,503	590	998	136	453	136	363
Catfish	544	157	222	518	726	1,814	1,043	1,043	363	1,043
Black drum	0	0	0	0	0	227	272	0	0	0
Red drum	0	0	0	0	45	0	181	499	136	0
Hickory shad	318	384	291	725	91	227	91	136	181	91
Spotted sea trout	0	0	0	324	227	2,500	1,800	181	181	0
American shad	43,591	25,568	25,439	33,912	26,263	20,412	8,618	20,820	54,432	57,607
Sturgeon	726	23	1,967	551	136	45	363	862	454	227
Suckers	0	0	0	0	0	0	91	0	0	0
Common eels	0	0	0	0	0	91	0	45	0	45
Mullet	0	0	0	0	0	227	0	91	0	0
Striped bass	816	735	1,013	1,071	0	0	0	0	0	0

^aAdapted from Du Pont (1982).

Table C-19. Commercial landing data for shellfish taken from coastal regions of Savannah River, 1972-1979^a

Year	Shellfish catch (kg)			
	Clams	Blue crabs	Oysters	Shrimp
1972	--	419,489 ^b	1,451 ^c	115,940 ^c
1973	862 ^d	543,957 ^b	2,858 ^c	222,128 ^c
1974	--	1,252,072 ^e	6,804 ^e	1,141,530 ^e
1975	--	17,237 ^b	3,447 ^e	1,264,818 ^e
1976	--	--	--	--
1977	--	63,504 ^b	19,051 ^e	626,286 ^e
1978	1,860 ^d	68,040 ^b	--	731,475 ^e
1979	454 ^d	104,781 ^b	9,072 ^b	--

^aAdapted from Du Pont (1982).

^bWassaw Sound plus Ossabaw Sound.

^cDOE (1982); T. Flowers, NMPS, personal communication.

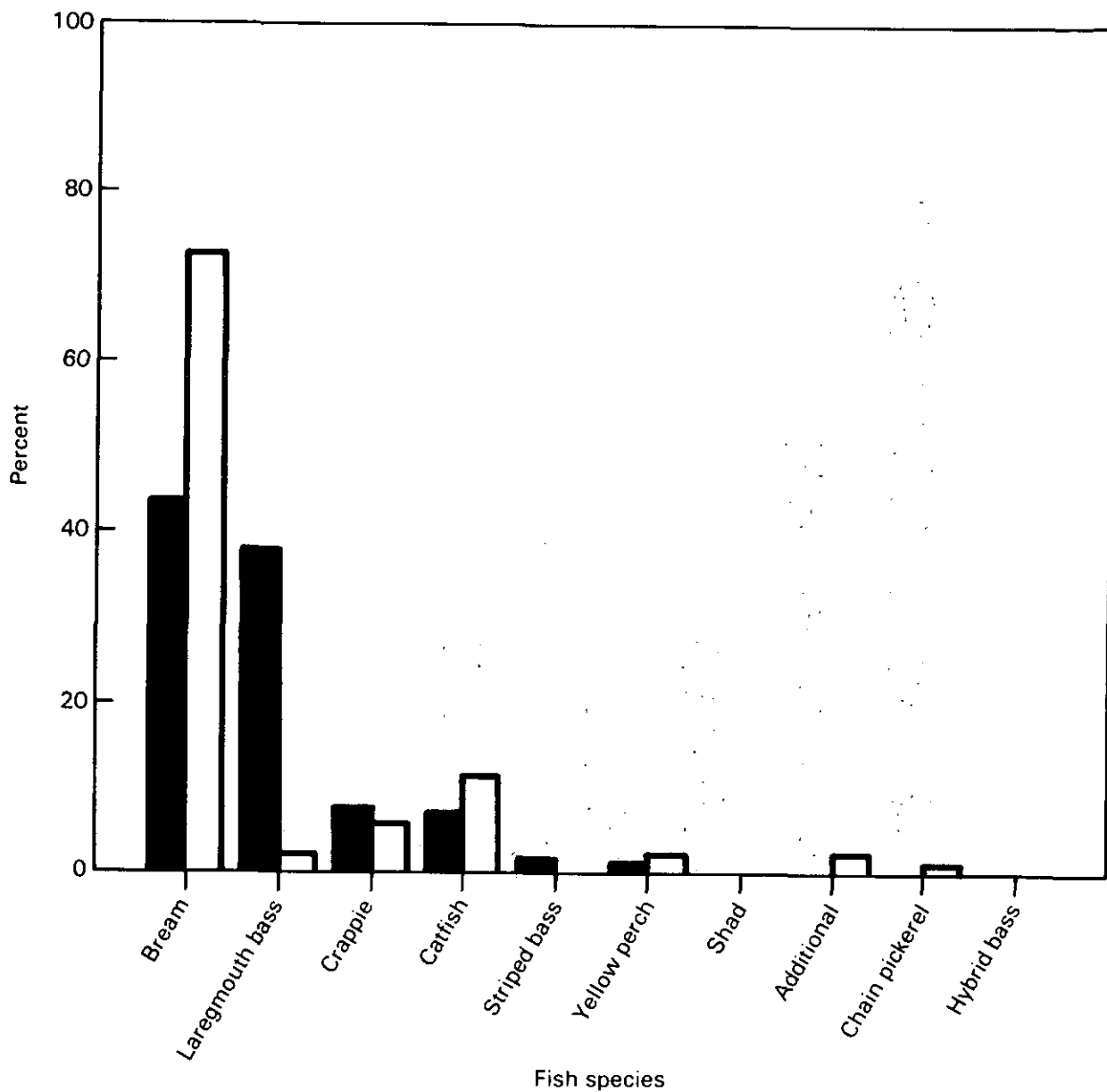
^dSavannah River landings.

^eNorthern District, Georgia.

Table C-20. Sports fishing on the Savannah River below New Savannah Bluff Lock and Dam

Fishing effort	Range ^a
Number of trips	70,054-85,848
Number of hours	305,398-399,222
Number of fish caught	456,235-644,329
Kilograms of fish	86,585-120,779
Total anglers	3,006-6,164
Trips per angler	12-22

^aRange is one standard deviation about the mean.



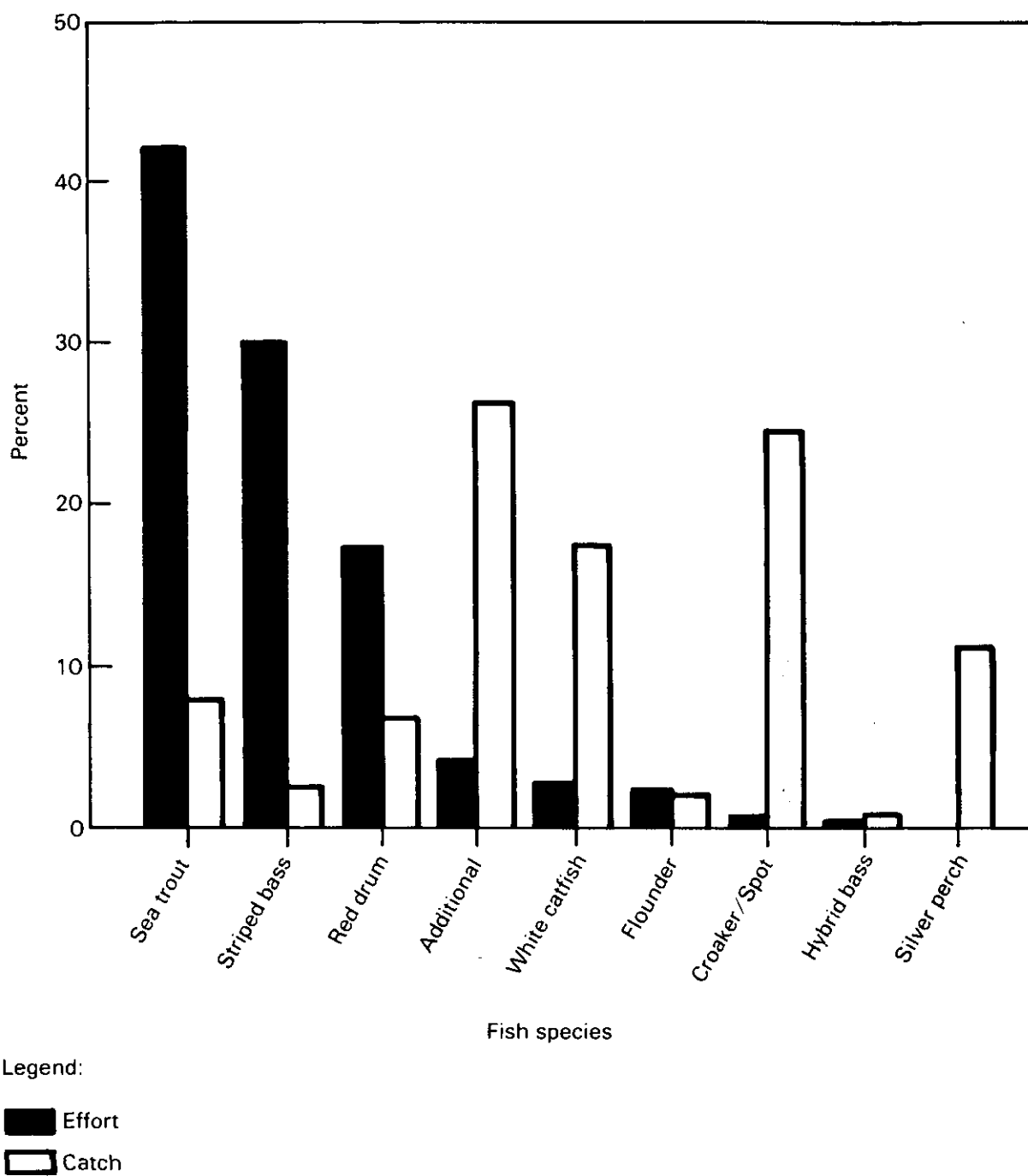
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■ Effort

□ Catch

Source: Du Pont (1983)

Figure C-19. Comparison of freshwater angler relative fishing effort and fish harvest by species.



Source: Du Pont (1983)

Figure C-20. Comparison of estuarine angler relative fishing effort and fish harvest by species.

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APPENDIX D

RADIOCESIUM AND RADIOCOBALT INVENTORY AND TRANSPORT

This appendix discusses the releases of radiocesium (principally cesium-137) and radiocobalt (cobalt-60) to the Steel Creek system; describes the estimated distribution and inventory of these materials in the sediments, biota, and water of the creek, swamp, and Savannah River; examines their transport offsite; and predicts the concentrations in the Savannah River and downstream water treatment plants as a result of resumption of L-Reactor operation (reference case--direct discharge). This appendix is also the basis for discussions associated with the preferred cooling-water alternative (see Appendix L).

TC

D.1 RELEASES OF RADIOCESIUM AND RADIOCOBALT

D.1.1 SRP releases

The principal sources of radiocesium and radiocobalt in the environment at SRP have been the reactor effluent discharges to onsite streams. These releases began in 1955, with the period of major reactor discharges occurring between 1955 and 1968.

From 1955 through 1980, about 560 curies of radiocesium have been discharged to onsite streams, approximately 284 curies of which were discharged to Steel Creek (Table D-1). These discharges resulted from leaching of reactor fuel elements with cladding failures which exposed the underlying fuel to water. The direct sources of these releases were heat exchanger cooling water, spent fuel storage and disassembly basin effluents, and process water from P- and L-Reactor areas (Figure D-1). A sharp decrease in the release of radiocesium (cesium-134 and cesium-137 in a ratio of 1:20, respectively; for ease of discussion, radiocesium will usually be referred to as cesium-137) occurred in the late 1960s and early 1970s when, (1) P-Reactor basin was fitted with sand filters and the basin water was demineralized before its release; and (2) the leaking fuel elements were removed to an environmentally safe storage area (L-Reactor is now equipped with a sand filter and ion exchange resin beds like those at P-Reactor).

A total of 66 curies of cobalt-60, formed by neutron activation of stainless steel in the reactors, has been discharged to SRP streams in the years following L-Reactor startup. An estimated 27 curies (15 from L-Reactor and 12 from P-Reactor) of this total was discharged to Steel Creek. Most of the cobalt-60 (half-life 5.26 years) has been eliminated through radioactive decay; however, an estimated 2.1 curies remain today either in Steel Creek or transported to the Savannah River system in a manner similar to radiocesium. This inventory is significantly less than the remaining cesium inventory in Steel Creek of 67 curies, 14 percent of which occurs above the L-Reactor outfall.

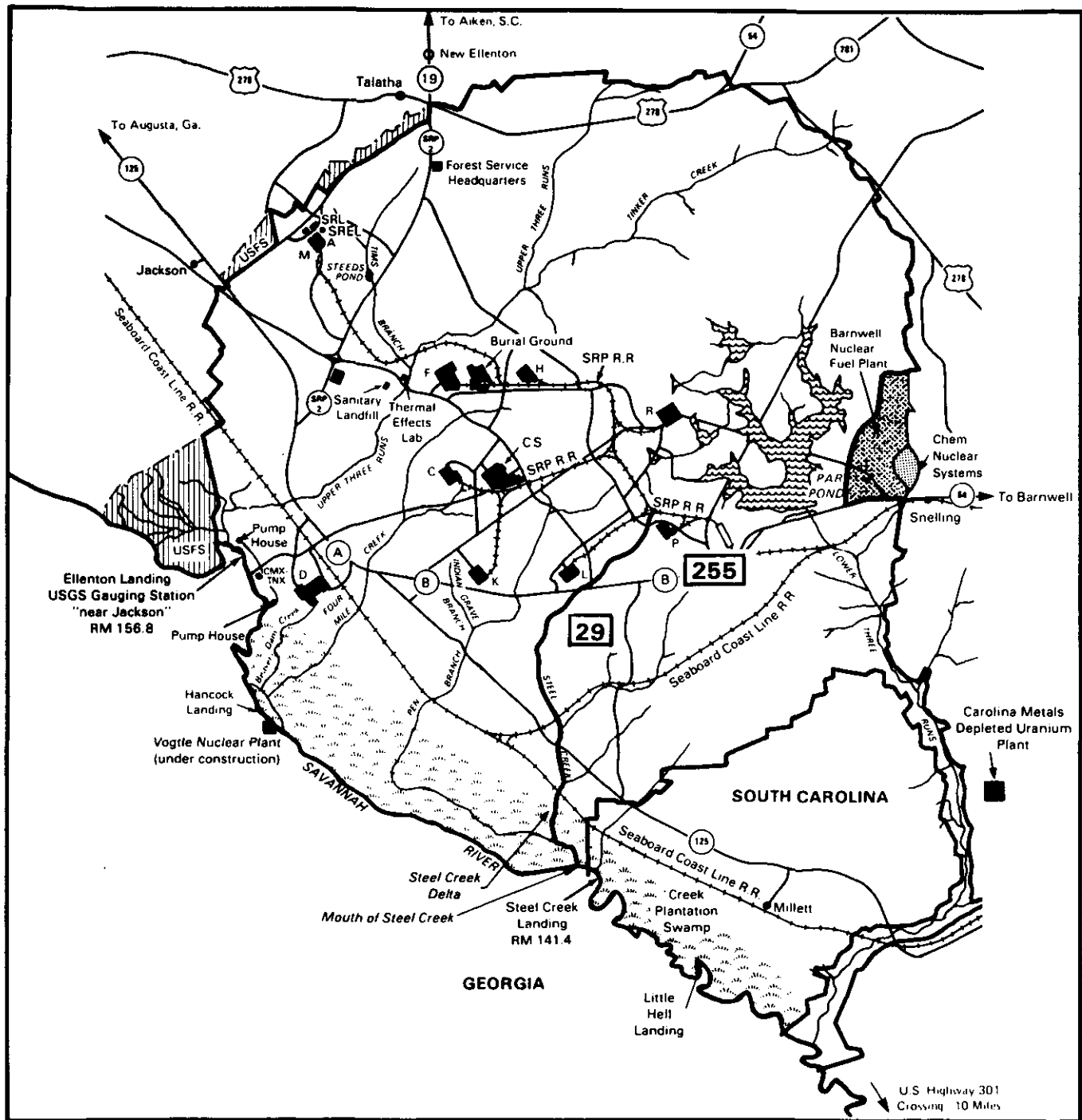
After their discharge to Steel Creek, the cesium-137 and cobalt-60 became primarily associated with the silts and clays in the Steel Creek system. The sediments and associated radionuclides have been subjected to continued resuspension, transport, and deposition according to the flow regime in the creek.

Table D-1. Cesium-137 release, transport, and accumulation in Steel Creek^a

Year	Incremental releases		Cumulative Cs-137 discharge corrected for decay (Ci)	Incremental Cs-137 transported past Road A in Steel Creek (Ci/year)
	P-Area (Ci/year)	L-Area (Ci/year)		
1955	0.2	0.2	0.4	-- ^b
1956	0.4	0.3	1.1	--
1957	1.1	0.7	2.9	--
1958	0.5	0.6	3.9	--
1959	0.7	1.6	6.1	--
1960	4.8	5.2	16.0	4.5
1961	4.2	1.0	20.8	6.1
1962	13.7	1.3	35.3	11.8
1963	9.0	0.9	44.4	9.2
1964	45.6	7.7	96.7	23.0
1965	29.8	1.3	125.6	20.0
1966	35.7	0.9	159.4	25.2
1967	45.1	0.7	201.5	20.3
1968	40.9	0.2	238.0	22.2
1969	13.1	3.4	249.1	14.7
1970	7.7	3.2	254.4	9.2
1971	1.3	0	249.9	1.6
1972	0.2	0	244.4	0.8
1973	0.2	0	239.0	0.8
1974	0.07	0	233.6	0.6
1975	0.04	0	228.4	0.5
1976	0.07	0	223.2	0.8
1977	0.09	0	218.2	0.3
1978	0.02	0	213.3	0.3
1979	0.02	0	208.5	0.4
1980	0.02	0	203.7	0.7
Total	255	29		

^aAdapted from Du Pont (1982a).

^bNot measured; assumed to be 0 in calculating the inventory above Road A. However, assuming that the fraction of the total release transported over the 1960-1980 period is applicable to the earlier period, it is estimated that 3.9 curies were transported past Road A from 1955 to 1959.



Legend:

C, K, R, L, P Reactor Areas (C, P, K are operating)
 F, H Separations Areas
 M Fuel and Target Fabrication
 D Heavy Water Production
 A Savannah River Laboratory and Administration Area
 CS Central Shop
 RM River Mile

Road A = Highway 125

Note: See Table D-1 for listing of the annual releases to Steel Creek.

Figure D-1. Savannah River Plant site showing total radiocesium releases to Steel Creek from L- and P-Areas.

D.1.2 Weapons test fallout

Atmospheric testing of nuclear weapons, mainly before the test ban treaty of 1963, caused 25,600,000 curies of cesium-137 to be deposited on the surface of the earth (United Nations, 1977; Miskel, 1973; Hayes, 1983c). The total resultant deposition was 2850 curies and 80 curies of cesium-137 in the 27,400 square kilometers of the Savannah River watershed and the 780 square kilometers of SRP, respectively. The deposited cesium-137 became attached to soil particles and has undergone only slow transport off the watershed. Results of routine monitoring by SRP indicate that since 1963 about 1 percent (about 32 curies) of the 2850 curies of cesium-137 deposited on the total Savannah River watershed has been transported down the river.

D.2 DISTRIBUTION OF RADIOCESIUM AND RADIOCOBALT

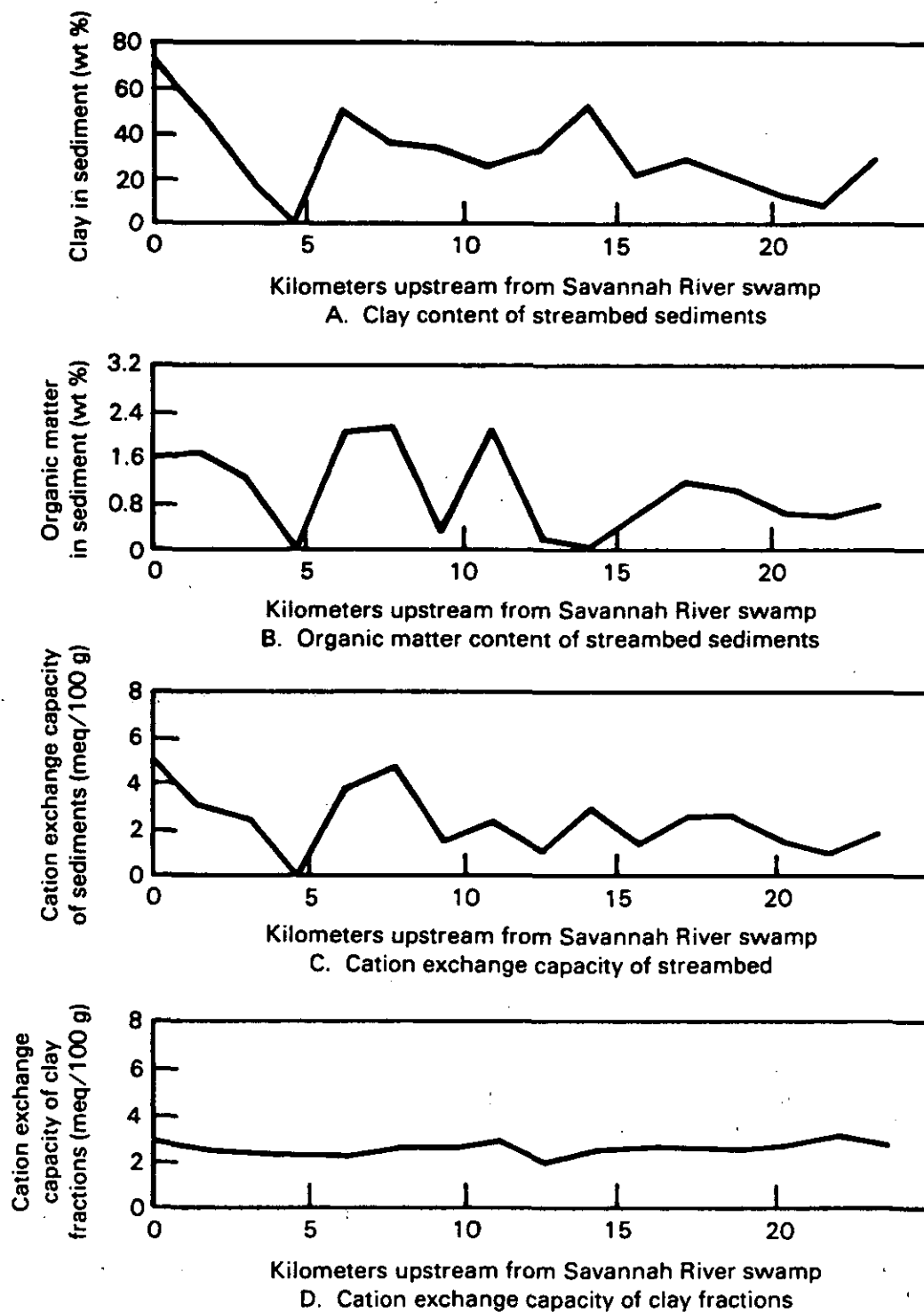
D.2.1 Sediments

D.2.1.1 Steel Creek sediments

Most of the cesium-137 that has been discharged to Steel Creek by SRP operations and weapons testing became associated with the silts and clays found in the streambed and suspended solids. The principal mechanisms for this association were (1) cation exchange with kaolinite and gibbsite clay minerals; (2) sorption on minerals; and (3) chelation with naturally occurring organic material. Figure D-2 shows the variation in ion-exchange capacity, clay content, and content of organic materials along the course of Steel Creek. A distribution coefficient of $K_d = 3960$, measured for sediments from Four Mile and Steel Creek (Kiser, 1979), and the work by Prout (1958), demonstrate the affinity of cesium-137 for the sediments and suspended solids in the Steel Creek system. Radiocobalt, because of its similar distribution coefficient, is expected to be associated with the sediment in the Steel Creek system in a manner similar to that of cesium-137.

As a result of these affinities, sedimentation and sorption processes control the distribution of cesium-137 and cobalt-60 in Steel Creek, its delta, and the adjoining Savannah River swamp. The resuspension, transport, and deposition of sediment are governed by the hydraulic properties of the sediment and streambed and by the creek's flow regime. Studies of Steel Creek (Ruby et al., 1981) indicate (1) erosional conditions exist in the reach from P-Reactor to about 2.5 kilometers above Road A; (2) neutral conditions exist in the reach from 2.5 kilometers above Road A to about 1.8 kilometers below Road A; and (3) depositional conditions exist in the 4- to 5-kilometer reach from 1.8 kilometers below Road A across the delta to the creek's mouth at the breach in the Savannah River levee.

Almost all sediment redistribution occurred during the period of major reactor discharges, between 1955 and 1968. Since 1968, little change has occurred in the sedimentation patterns or in the channel-delta configuration of Steel Creek (Ruby et al., 1981).



Source: Hawkins (1971).

Figure D-2. Variation of clay content, organic matter, and cation exchange capacity in Steel Creek as a function of distance.

Soil cores collected in 1974 in lower Steel Creek (Table D-2; Figure D-3) showed that (1) 69 percent of the cesium-137 was in the upper 20 centimeters; (2) 86 percent in the upper 40 centimeters; and nearly all of it was confined to the upper 100 centimeters (Brisbin et al., 1974). More extensive coring conducted in 1981 within the Steel Creek corridor and delta areas (Figure D-3; Table D-3; Figure D-4) confirmed these results; about 61 percent of the cesium-137 was found in the upper 20 centimeters and 83 percent in the upper 40 centimeters (Smith et al., 1982). Sediment samples taken in 1981 from the center of Steel Creek had lower cesium-137 concentrations than sediments taken from either bank (Figure D-5) (Smith et al., 1981). In addition, the fine-grained (clay and silt) creekbed and floodplain sediments are usually associated with higher cesium-137 concentrations than the coarser-grained sediments (Tables D-4 and D-5).

Table D-2. Distribution of radiocesium (pCi/g dry weight) in Steel Creek soils^a

Depth interval (cm)	Mean	Standard error	Range	Percentage of total Cs-137 inventory in interval
0-10	93.5	32.3	5.6-516.4	55
11-20	24.5	6.8	3.1-137.5	14
21-30	15.1	4.1	2.3-75.1	9
31-40	13.0	3.8	1.4-60.6	8
41-50	7.1	2.1	1.0-42.8	4
51-60	3.8	0.6	0.5-10.9	2
61-70	3.4	0.4	0.8-7.2	2
71-80	4.0	0.9	0.2-15.5	2
81-90	3.3	0.7	0.1-14.0	2
91-100	2.1	0.4	0.0-6.9	1
Total				100

^aAdapted from Brisbin et al. (1974); see Figure D-3 for sampling locations.

EV-6 | Studies between 1978 and 1981 showed concentrations of cobalt-60 in the Steel Creek floodplain sediments to be, on the average, about 15 times less than cesium-137 concentrations (Table D-6). No other man-made gamma activity radio-nuclides were detected above measurement sensitivities.

Gamma exposure measurements at one meter above ground level were conducted in Steel Creek along the 12 soil-sampling transects, and the results compared with radiocesium concentrations in one-meter-deep soil cores and vegetation

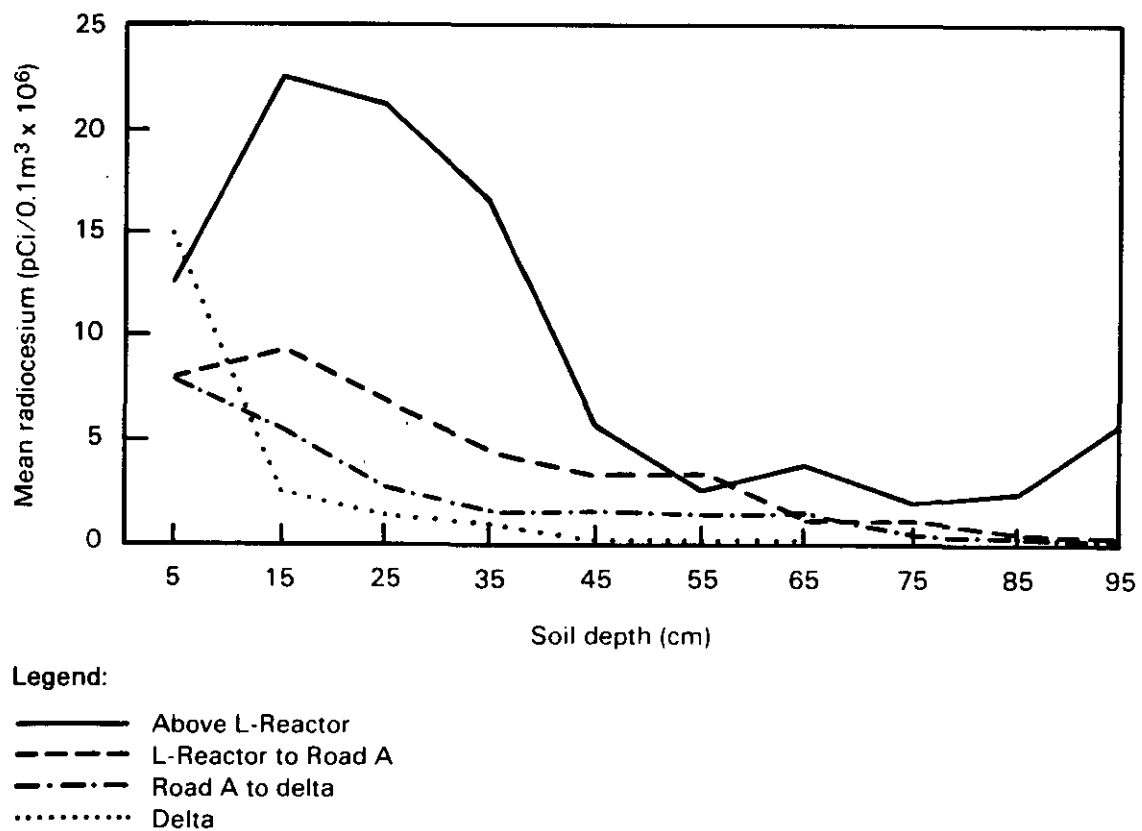
Table D-3. Estimated radiocesium concentrations at the sampled soil depths for the major Steel Creek sections and total Cs-137 for each section^a

EV-4	Depth (cm)	Major sections of Steel Creek ^b				Total curies	Percent of total
		P-Reactor to L-Reactor ($\mu\text{Ci}/\text{m}^2$)	L-Reactor to Road A ($\mu\text{Ci}/\text{m}^2$)	Road A to delta ($\mu\text{Ci}/\text{m}^2$)	Steel Creek delta ($\mu\text{Ci}/\text{m}^2$)		
	0-10	12.51	8.13	8.10	15.02	27.27	41
	10-20	22.21	9.45	5.35	2.63	13.70	20
	20-30	21.27	6.29	2.48	1.03	8.44	13
	30-40	16.80	4.67	1.56	0.85	6.33	9
	40-50	5.91	3.47	1.65	0.24	3.84	6
	50-60	2.41	3.45	1.31	0.15	3.23	5
	60-70	2.66	0.85	1.33	0.22	1.67	2
	70-80	1.88	0.93	0.56	0.17	1.23	2
	80-90	2.48	0.37	0.28	--	.61	1
	90-100	5.80	0.21	0.14	--	.76	1
	Total	93.93	37.82	22.76	20.31		100
	Area $\text{m}^2 \times 10^3$	97.48 (4%)	644.74 (28%)	458.02 (20%)	1138.71 (49%)	--	--
	Curies	9.16 (14%)	24.38 (36%)	10.42 (15%)	23.13 (34%)	67.09	--

^aAdapted from Smith et al., 1982; soil samples collected along transects shown in Figure D-3, as described in the reference.

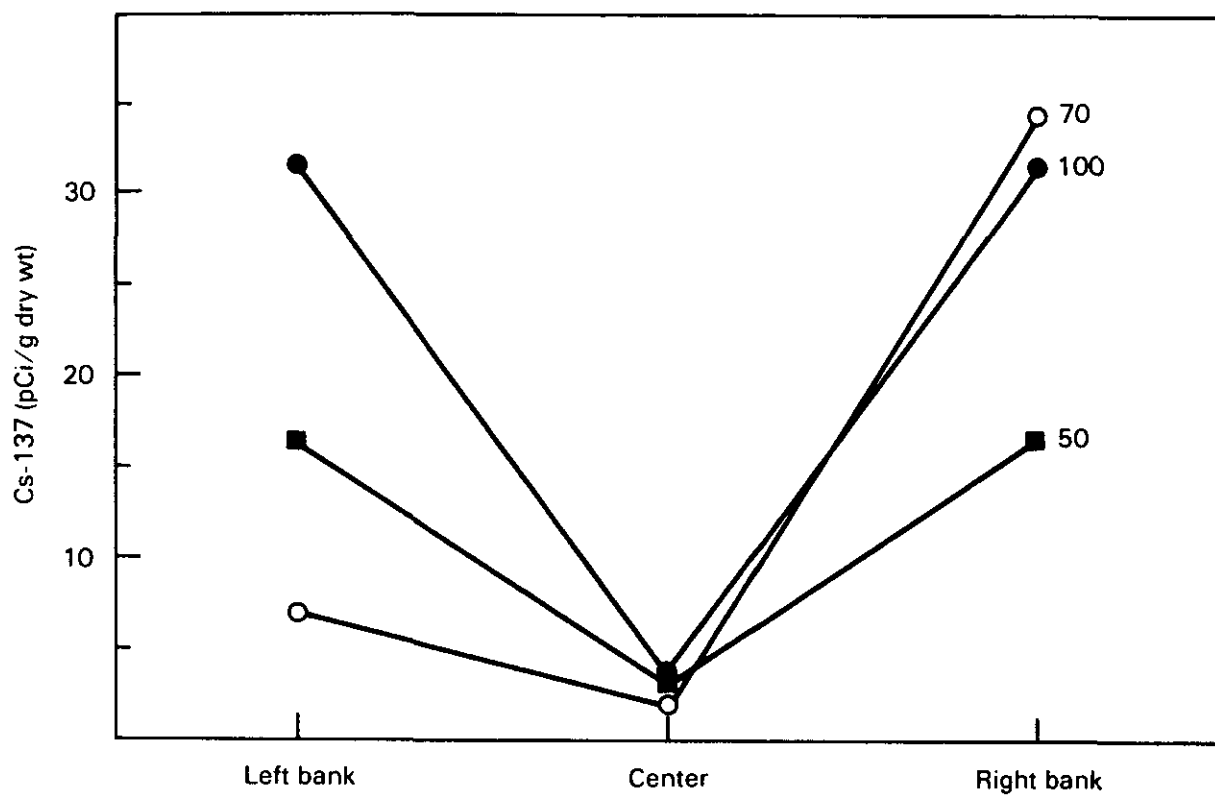
^bFigures D-1 and D-3 show the locations of these features.

samples (Gladden et al., 1982). Maximum exposure rates (Table D-7) were found at upstream transects near the sources of the contamination and downstream in the Steel Creek delta area. Mean exposure rates of 0.057 to 0.100 mR/hr were observed in the transects nearest P- and L-Reactors, and 0.092 mR/hr in the delta area. In general, the radiocesium content ($\text{pCi}/0.1 \text{ m}^3$) in the surface soils was the most important variable for explaining variations in exposure rates. The relative importance of the other variables [plant concentration (pCi/g), soil concentration (pCi/g) as a function of depth, and soil texture] varied substantially along the length of Steel Creek (Gladden et al., 1982). Based on the gamma exposure rate data, radiocesium concentrations in the Steel Creek system can be characterized as nonuniformly distributed across the floodplain. Replicate transects within locations (any of the 12 transect locations) show little similarity in either the locations or magnitudes of the gamma exposure rates.



Source: Smith et al. (1982).

Figure D-4. Radiocesium concentrations in soil cores collected in Steel Creek (1981).



Legend:

- Transect 70
- Transect 100
- Transect 50

Note: Sampling transects shown on Figure D-3.

Source: Smith et al. (1981).

Figure D-5. Concentrations of radiocesium in midstream and stream bank sediment samples collected in Steel Creek (1981) at locations 50, 70, and 100.

Table D-4. Range of Cs-137 concentrations (pCi/g dry weight) of soil types in Steel Creek (1981)^a

Soil type ^b	N ^c	% total	Mean	Standard error
1 (clay)	101	19.24	137.08	19.82
2	108	20.57	80.47	15.52
3	127	24.19	38.50	7.10
4	83	15.81	54.86	12.02
5 (sand)	106	20.19	17.23	2.99

^aAdapted from Smith et al. (1981); data represent all soil samples collected along the 12 transects shown in Figure D-3.

^bSoil samples were graded visually from 1 to 5, according to their "average" particle size; samples with the highest clay content are type 1 and those with the least clay and silt (i.e., predominantly sand) are type 5.

^cN = Number of soil samples.

EV-11

Table D-5. Mean radiocesium concentration (pCi/g) in soil column by soil size category^a

Location ^c	Soil type ^b				
	1(fine)	2	3	4	5(coarse)
Above					
L-Reactor	166	104	62	117	43
L-Reactor to					
Road A	171	112	38	36	8
Road A to					
delta	78	46	18	21	9
Delta	219	59	13	24	17

^aAdapted from Smith et al., 1982.

^bSoil samples were graded visually from 1 to 5, according to their "average" particle size; samples with the highest clay content are type 1 and those with the least clay and silt (i.e., predominantly sand) are type 5.

^cFigures D-1 and D-3 show the locations of these features.

Table D-6. Co-60 and Cs-137 in Steel Creek sediments^a

Year	Road B			Steel Creek at Swamp		
	Co-60 pCi/g	Cs-137 pCi/g	Co-60 Cs-137	Co-60 pCi/g	Cs-137 pCi/g	Co-60 Cs-137
EV-8 1978	1.7	45	0.038	7.5	67	0.112
1979	1.7	50	0.034	1.5	61	0.025
1980	0.6	3.5	0.171	---	10	---
1981	0.9	42	0.021	1.2	2	0.6 ^b
EV-8	Rd B + at swamp average is 0.067 ± 0.061					

^aSource: Hayes and Watts, 1983; locations of Road B and Swamp shown in Figure D-1.

^bOutlier, not used to develop average ratio.

Table D-7. Mean and range of gamma exposure readings at sampling locations along Steel Creek^a

Transect location ^b	Number of observations	Mean (mR/hr)	Range
EV-13 10	60	0.057	0.010-0.500
20	63	0.132	0.005-0.950
30	86	0.091	0.015-0.350
40	93	0.100	0.020-0.375
50	122	0.039	0.010-0.129
60	76	0.040	0.016-0.073
70	97	0.053	0.015-0.400
80	166	0.044	0.015-0.375
90	160	0.054	0.013-0.375
100	198	0.051	0.010-0.150
EV-13 110	138	0.033	0.014-0.129
120	592	0.092	0.002-0.550
10-120	1851	0.068	0.002-0.950

^aAdapted from Gladden et al., 1982.

^bLocation of transects shown in Figure D-3.

D.2.1.2 Savannah River swamp sediments

Beginning in 1974, comprehensive radiological surveys were made in the Savannah River swamp, including the 1235-acre uninhabited, privately owned Creek Plantation Swamp (Figure D-6), and of the soil and the vegetation. Because no significant changes were observed in the mean concentration of cesium-137 in soil samples from 1976 (34.1 ± 50.3 picocuries per gram) to 1977 (39.9 ± 57.4 picocuries per gram), the 1978 survey included only thermoluminescent dosimeter (TLD) measurements. Provisions were made to conduct comprehensive surveys at 5-year intervals (Ashley and Zeigler, 1981). Soil cores collected in 1974 showed that about 70 percent of the cesium-137 was confined to the upper 6 to 7 centimeters, but that cesium was detectable at depths of 25 centimeters (Ashley and Zeigler, 1975). The 1982 values are appreciably less than those for 1974, but slightly lower on the average than those for 1977. Mean values at comparable locations averaged 33.3 (1982), 39.8 (1977), and 75.9 picocuries per gram (1974) (Du Pont, 1983b). In 1982, TLD measurements ranged from a minimum of 0.14 milliroentgen per day to maximum of 1.09 milliroentgen per day, both measured on Trail 1 (Figure D-6). The 1972-to-1980 average values ranged from 0.20 milliroentgen per day on Trail 9 to 1.46 milliroentgen per day on Trail 1 (Du Pont, 1983b).

EV-14

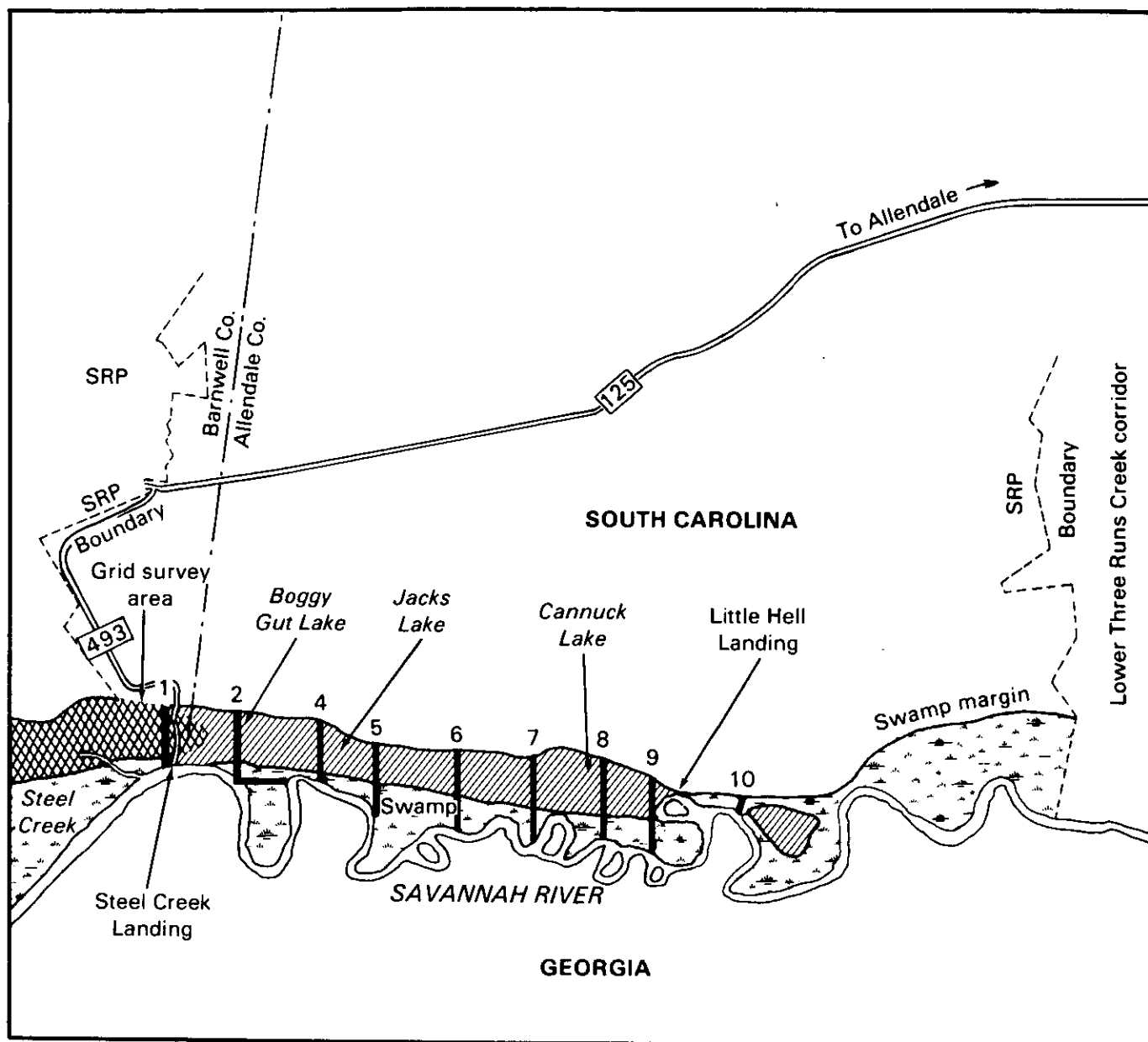
EV-14

D.2.1.3 Savannah River sediments

Turbulence in the Savannah River generally keeps the fine soils particles in suspension. These particles are deposited where the river velocity and turbulence are low, such as inside river bends and downstream from obstructions, Oxbow Lakes, and portions of the floodplain. Sediments from such locations upstream from the Savannah River Plant normally have about 1.0 picocurie per gram or less of radiocesium (Du Pont, 1982a). In 1974, riverbed sediments from downstream of the Savannah River Plant contained radiocesium concentrations from about 2.0 picocuries per gram at the U.S. Highway 301 bridge (River Mile 118.7 near Millhaven, Georgia) to 6.5 picocuries per gram at the Georgia Highway 119 bridge (River Mile 61.5, near Clyo, Georgia). Table D-8 summarizes more recent monitoring data for the Savannah River.

D.2.1.4 Holding pond sediment

A radiological survey of the raw water and backwash holding pond sediments at the Beaufort-Jasper water treatment plant was performed in November 1982. Cesium-137 concentrations in the sediment from the raw water holding pond are about one-tenth those from the backwash pond sediment, which is principally floc (Table D-9). Backwash floc from the North Augusta water treatment plant has cesium-137 and K-40 concentrations similar to those at the Beaufort-Jasper plant. These cesium-137 concentrations are low and within the concentration range of cesium-137 in sediments from other locations in South Carolina not influenced by SRP (Hayes, 1983d).



Legend:

 Detectable Cs-137 deposition

 Area of highest Cs-137 deposition

Total contaminated offsite area is 940 acres

0 1 2 3 4 kilometers



Figure D-6. Location of transects used for collection of soil cores and vegetation samples in Savannah River Swamp, including the 1235-acre Creek Plantation Swamp.

Table D-8. Cesium-137 concentration (pCi/g dry weight) in Savannah River sediments (8-cm depth)^a

Location	River mile	Average 1975-1979	1980	1981	1982
Dernier's Landing ^b	160.5	0.5	0.2	0.07	0.03
Below Four Mile Creek	150.2	0.7	0.2	0.4	0.25
Above Little Hell Landing	136.6	0.8	0.2	0.7	0.7
Below Little Hell Landing	134.0	3.9	0.4	0.5	0.1
Above Lower Three Runs Creek	129.5	0.8	0.4	0.5	-
U.S. Highway 301 bridge	118.7	1.7	1.1	0.07	0.5
S.C. Highway 119 bridge	61.5	6.5 ^c	- ^d	-	-

^aSource: Ashley and Zeigler, 1976, 1978a, 1978b, 1981.

^bControl above Plant.

^cBased on 1975 data only.

^dNo analysis performed.

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Table D-9. Gamma pulse height analyses of sediment core samples Beaufort-Jasper and North Augusta water treatment plants, 11/8/82^a

Location	Depth (cm)	Dry Weight gms	Cs-137 pCi/gm	K-40 pCi/gm
Beaufort-Jasper				
Raw Water Holding Pond	0 - 2.4	504	0.08 ± 0.07	2.8 ± 0.9
	2.4 - 4.7	164	0.05 ± 0.16	4.0 ± 2.3
Backwash Pond #1 ^b	0 - 2.4	5	0.20 ± 5.2	5.4 ± 73
	2.4 - 4.7	10	.96 ± 2.5	0 ± 34
	4.7 - 7.1	57	.29 ± 0.44	1.6 ± 6.0
	7.1 - 9.4	39	.52 ± .64	0.3 ± 8.7
	9.4 -11.8	14	.71 ± 1.7	0 ± 23
Backwash Pond #2 ^b	0 - 2.4	5	0.92 ± 4.5	0 ± 62
	2.4 - 4.7	12	.72 ± 2.0	2.3 ± 27
	4.7 - 7.1	20	.46 ± 1.2	0 ± 17
	7.1 - 9.4	24	.96 ± 1.0	0 ± 14
	9.4 -11.8	25	.92 ± 1.0	0 ± 14
	9.4 -14.2	54	.44 ± 0.5	4.2 ± 6.5
	14.2 -16.5	19	.79 ± 1.3	5.6 ± 18
	16.5 -18.9	8	1.1 ± 3.0	3.6 ± 42
Composite Backwash Ponds		291	0.48 ± 0.03	3.3 ± 0.5
Ponds 1 & 2				
North Augusta				
(Primarily Floc)		41	0.54 ± 0.12	2 ± 1.5

^aAdapted from Du Pont (1983b).

^bThe backwash pond sediments contained primarily floc which when dried contained only small quantities of material.

D.2.2 Biota

During the period of major reactor discharges of cesium-137, 1955 to 1968, Steel Creek was subjected to heated discharges as much as 20 times its normal unheated flow. There was pronounced vegetation mortality; most arboreal species on the Steel Creek floodplain and delta were lost. The vegetation kill zone projected well beyond the distal end of the Steel Creek delta and downstream in the Savannah River swamp (Smith et al., 1982). When the reactor discharges were discontinued, natural succession began to revegetate. This process is still active, but slow (Martin et al., 1977; Ruby et al., 1981).

Vegetation samples collected in Steel Creek (Figure D-7) from 1970 to 1979 show (Table D-10) annual reductions in cesium-137 concentrations from 1970 through 1973. Concentrations remained fairly constant from 1973 to 1976 (Ashley and Zeigler, 1981; Du Pont, 1982a). Du Pont (1982a) suggested that the high concentrations in 1977 were due to the uptake of cesium-137 desorbed and resuspended during the 1976 heated discharge to Steel Creek from P-Area (see Section D.4). Results of additional vegetation samples collected (Figure D-3) in 1981 are presented in Smith et al. (1982), and summarized in Table D-11.

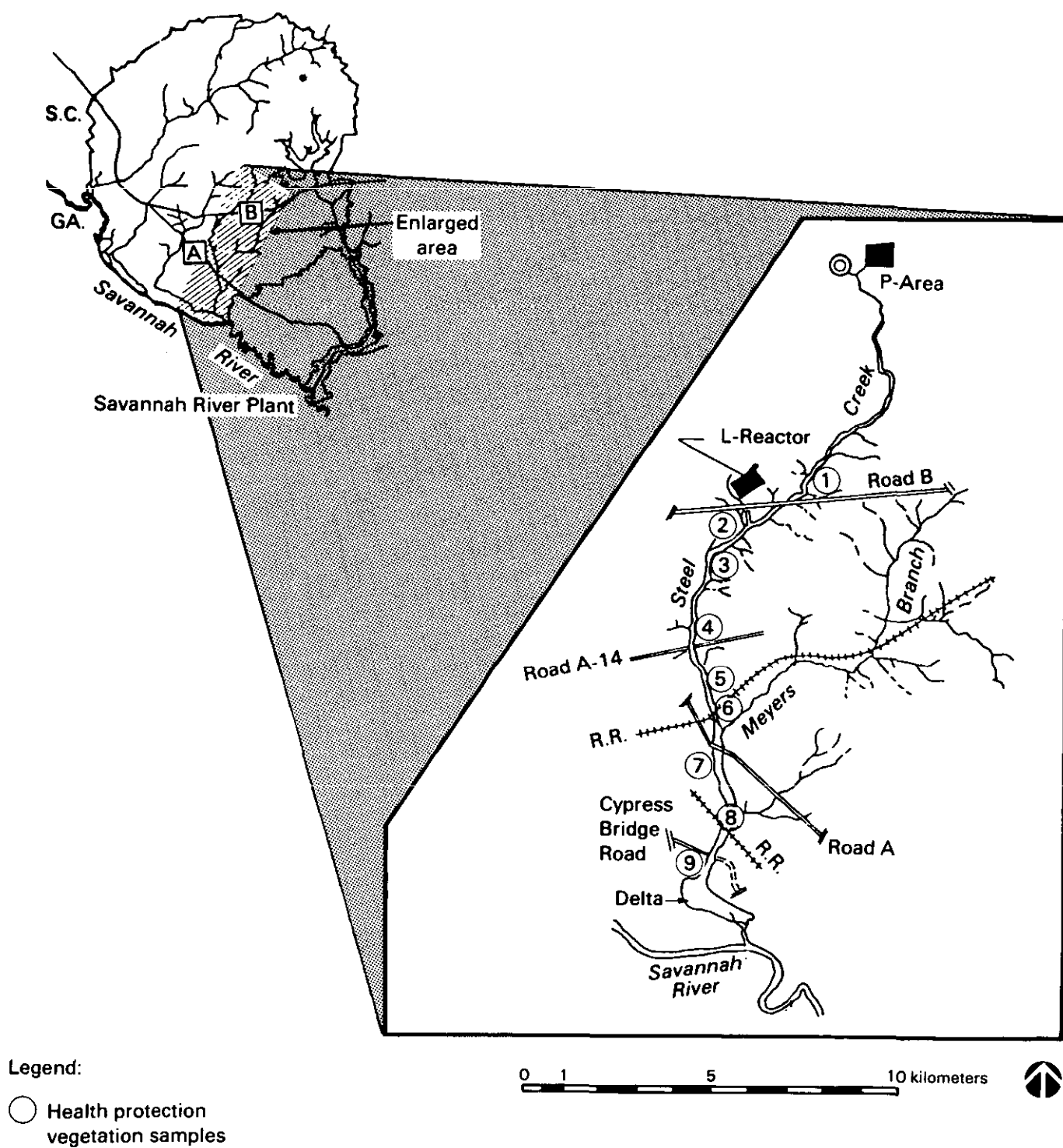
Table D-10. Average radiocesium concentrations in vegetation from Steel Creek^a

Sample Point ^b	Average Cs-137 concentration (pCi/g dry weight) ^c									
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	600	310	150	210	380	240	420	1000	160	110
1	2200	360	20	340	280	220	250	1300	520	270
2	1000	890	150	120	160	240	400	1800	770	310
3	1300	660	450	360	210	380	360	420	270	250
4	220	1100	340	280	310	180	230	410	250	200
5	1960	510	360	210	210	200	100	420	220	200
6	1100	1100	770	220	260	160	390	220	150	130
7	1600	660	290	240	220	220	180	250	210	83
8	1100	570	460	190	130	110	170	220	160	110
9	260	160	380	210	190	190	190	210	170	140
Mean	1134	632	337	238	235	214	269	625	288	180
Standard deviation	664	320	208	71	74	70	114	553	201	77

^aAdapted from Du Pont (1982a).

^bLocation of transects are shown on Figure D-7; vegetation sampled was primarily cattails, duckweed, and knotweed.

^cThe period from 1962-1969 was associated with high release rates to Steel Creek, averaging 31.2 Ci/year; thereafter, the releases were substantially less, averaging 0.58 Ci/year (see Table D-1).



Source: DuPont (1982a).

TC

Figure D-7. Location of transects used for collection of vegetation samples in Steel Creek (1970 to 1979).

Table D-11. Cesium-137 concentration in vegetation samples (1981)

Vegetation type	Concentration (pCi/g dry wt)			
	Herb. leaf	Herb. stem	Woody leaf	Woody stem
Mean	228.6	142.7	131.5	98.8
Standard error	23.4	8.8	9.7	7.6
Sample size	145	145	123	122

Changes in the cesium-137 concentrations that have occurred in selected plants and insects from the Steel Creek watershed between 1971 and 1981 are listed in Table D-12.

From 1974 to 1977, annual surveys in the Savannah River swamp (Figure D-6) included soil, vegetation, and TLD measurements. Results of the 1982 comprehensive vegetation survey are compared in Du Pont (1983b) with those from 1977 and previous years. The average cesium-137 concentrations in vegetation from the Savannah River swamp are generally less than those in vegetation from Steel Creek (Ashley and Zeigler, 1981; Du Pont, 1983b). In 1983, the maximum concentration in the swamp was 58 ± 16 picocuries per gram (dry weight), or about one-third the mean value listed in Table D-10 for the Steel Creek corridor.

Table D-12. Cesium-137 concentrations in selected plants and insects (picocurie per milligram dry wt)^a

	1971						1981		
	Floodplain			Islands					
	N	$\bar{X}$	(SE)	N	$\bar{X}$	(SE)	N	$\bar{X}$	(SE)
Plant genera									
<u>Alnus</u>	10	0.37	(0.06)	8	1.00	(0.28)	13	0.12	(0.01)
<u>Myrica</u>	10	0.54	(0.28)	8	1.50	(0.78)	15	0.07	(0.008)
<u>Salix</u>	10	0.51	(0.28)	10	1.60	(0.59)	17	0.26	(0.04)
Arthropod orders									
Araneae	25	0.26	(0.07)	25	0.97	(0.17)	16	0.06	(0.002)
Coleoptera	25	0.44	(0.29)	24	0.99	(0.19)	13	0.02	(0.005)
Orthoptera	25	0.40	(0.08)	25	1.50	(0.28)	18	0.09	(0.01)

^aSource: Brisbin et al., 1982.

Abbreviations: N = sample size

$\bar{X}$ = mean value

SE = standard error

Cesium-137 concentrations in the muscle tissue (edible parts) of deer and hogs killed by hunters at SRP are reported annually; concentrations in 1982 averaged 13.8 pCi/g for deer and 5.8 pCi/g for hogs (Du Pont, 1983b). In a recent study, Watts et al. (1983) found that the cesium-137 distributions for

deer (from 1975 to 1979) at SRP and the South Carolina Coastal Plain are quantitatively described by a log normal distribution. For these five years, deer on the Coastal Plain exhibited concentrations that were higher statistically than those at SRP, at the 0.005 significance level for three years and at the 0.05 significance level for two years.

EV-25

Domby et al. (1977) found that heron nestlings near Par Pond had body burdens ranging from less than 5 pCi/g wet weight to 27.4 pCi/g wet weight, depending on the species. Waterfowl have been shown to be effective vectors of radionuclide transport from systems and to display dramatic changes in body burden due to subtle migratory patterns (Brisbin et al., 1973; Hanson and Case, 1963). Differences in radiocesium body burdens of birds at the SRP is discussed by Stanley et al. (1975) and shown to be related to season, diet, and location (see also Willard, 1960).

The Steel Creek delta and the Savannah River swamp provides roosting and feeding habitat for migratory ducks. Several areas in Steel Creek near Road A and Road B are wide and shallow, have slow-moving water, and are relatively unobstructed by trees. Wood ducks are known to nest in these areas, and the cesium concentration in flesh from these ducks reflects their cesium-contaminated environment, with average cesium-137 concentrations of 25 to 67 pCi/g in Steel Creek and somewhat lower in the swamp (Marter, 1974). Transient ducks from the Steel Creek Swamp have cesium-137 concentrations of 8 pCi/g, comparable to the concentrations in transient ducks obtained from Par Pond (Marter, 1974).

Concentration of cesium-137 in wildlife from Creek Plantation Swamp is reported to be less than 3.8 pCi/g wet weight (Du Pont, 1982a). Concentration of cesium-137 in muscle tissue and liver samples from furbearing animals captured near Steel Creek averaged 6 pCi/g and 5 pCi/g, respectively, comparable to concentrations found in similar animals captured near Upper Three Runs Creek (Marter, 1974).

Table D-13 lists the average values of cesium-137 in fish taken from Steel Creek and the Savannah River below the creek. In general, the concentrations of cesium-137 decrease with increasing distance from the contaminated creekbed sediments.

Concentrations in Savannah River fish are lower than those measured in fish from Steel Creek (Du Pont, 1982a). Whole-body bioaccumulation factors (cesium-137 concentrations in fish/cesium-137 concentrations in water) for fish taken from the river at the U.S. Highway 301 bridge from 1965 to 1970 average about 2300 (Table D-14). The mean bioaccumulation factor for 20 species of fish (527 specimens) from Steel Creek was found to be 2019 (whole-body) and 3029 (flesh) (Smith et al., 1982; Ribble and Smith, 1983). In contrast, largemouth bass from Par Pond exhibit bioaccumulation factors (flesh) that average about 1200 (Harvey, 1964). Whole-body bioaccumulation factors determined for fish from Lower Three Runs Creek are reported in Table D-15. A fish flesh bioaccumulation factor of 3000, 1.5 times the value recommended in the NRC LADTAP-II computer code (Simpson and McGill, 1980), was chosen for dose assessment analyses in this document.

Table D-13. Measured annual mean radiocesium concentration in fish from Steel Creek, swamp, and the Savannah River^a

Year	Species	N ^b	Mean radiocesium content, pCi/g wet weight			
			Steel Creek			Savannah River Steel Creek to Hwy 301 bridge ^c
			Road A	Mouth	Swamp	
1962	---	---	---	---	10	2 ^e
1963	--	--	--	--	10	2 ^e
1964	--	--	--	--	13	1 ^e
1965	--	--	--	--	66	5-8 ^f
1966	--	--	--	--	27	8-3 ^f
1967	--	--	--	--	40	17-3.5 ^f
1968	--	--	1250	--	43	7-2.5 ^f
1969	--	--	1500	--	64	4-4 ^f
1970	--	--	590	--	44	2-1.5 ^f
1977	Bream	1	3.9	--	--	--
1977	Bream	5	--	0.4	--	--
1977	Catfish	1	2.8	--	--	--
1978	Bream	8	20	--	--	--
1978	Bream	4	--	2	--	--
1978	Bass	4	--	1	--	--
1981	Largemouth bass	53	20.1	--	--	--
1981	Blackband darter	36	15.0	--	--	--
1981	American eel	44	10.0	--	--	--
1981	Shiners	57	9.5	--	--	--
1981	Pirate perch	48	8.2	--	--	--
1981	Creek chubsucker	41	8.5	--	--	--
1981	Spotted sunfish	49	8.0	--	--	--
1981	Redbreasted sunfish	45	7.5	--	--	--
1981	Savannah darter	31	3.4	--	--	--
1981	Mean fish (20 species)	527	10.7	--	--	--
1981	Bream	31	--	--	--	0.09
1981	Bass	3	--	--	--	0.12
1981	Catfish	13	--	--	--	0.10
1981	Carp	2	--	--	--	1.45
1981	Eel	1	--	--	--	0.06
1981	Other species	18	--	--	--	0.05

^aAdapted from Marter, 1970a; Du Pont, 1982a,b; Ribble and Smith, 1983.

^bN is the number of specimens analyzed.

^cAt U.S. Highway 301 bridge (near Millhaven, Georgia) unless otherwise noted.

^dData not available or not provided.

^eBelow mouth of Steel Creek.

^fValue for below mouth of Steel Creek is listed first followed by the value for Hwy 301 bridge.

Table D-14. Radiocesium whole body bioaccumulation factors for fish from Steel Creek and the Savannah River^a

Year	Steel Creek		Savannah River	
	Road A		Below Steel Creek	Hwy 301 bridge
	Maximum	Average	Average	Average
1965			1626	3902
1966			1975	1111
1967			5528	1707
1968	2385	1355	4058	2174
1969	5490	2353	4848	7273
1970	3958	1639	1111	1250
1981	3792 ^b	2019 ^c	--	--

Arithmetic
mean

-- 1842 3191 2903

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Geometric
mean

-- 1802 2700 2295

Weighted average of arithmetic means^d = 2565

Weighted average of geometric means^d = 2188

TC

^aAdapted from Marter, 1970a,b; Du Pont, 1982a; Smith et al., 1982.

^bMean of 53 specimens of largemouth bass; this species had the maximum whole-body bioaccumulation factors measured in 1981. The maximum bioaccumulation factor measured for largemouth bass was 4780. One specimen of American eel had a bioaccumulation factor of 8300.

^cMean of 527 specimens representing 20 species.

^dSteel Creek data are weighted by a factor of 2 because the fish lived in an environment more highly contaminated by cesium-137 than the Savannah River.

TC

Table D-15. Radiocesium whole-body bioaccumulation factors for fish from Lower Three Runs Creek^a

Species	Mean bioaccumulation factor (1971-1974)	Number of individuals
Dollar sunfish	691	5
Pike/pickerel	908	6
Redbreast sunfish	1334	3
Bass	2803	4

^aAdapted from Shure and Gottschalk, 1976.

D.2.3 Water

D.2.3.1 Steel Creek

During 1982, the concentration of cesium-137 in Steel Creek at the Cypress Bridge monitoring station averaged about 3 pCi/l. This concentration is about the same as during the previous 5 years.

V-30| In November and December 1981, seven water samples from Steel Creek between Road A and the delta were analyzed for their cesium-137 content (Ribble and Smith, 1983). The concentrations ranged from 3.9 to 7.9 pCi/l and had a mean value of 5.3 ± 1.81 picocuries per liter (with a mean potassium concentration of 0.99 mg/l). About 84 percent of this value was associated with the dissolved fraction and 16 percent with the suspended solid fraction. Shure and Gottschalk (1976) similarly found that about 20 percent or less of the cesium-137 in water samples from Lower Three Runs Creek was associated with the suspended solid fraction.

It is estimated that November and December 1981 concentrations of cobalt-60 averaged about 0.3 picocurie per liter. This estimate is based on cesium-137 and cobalt-60 measurements made during testing of the L-Reactor secondary cooling-water system conducted in the spring of 1982 (Hayes and Watts, 1983).

More recently, Hayes (1983e) reported the results of cesium-137 measurements in Steel Creek made from April through August 1983. During this period, the average transport of cesium-137 was 3.2 ± 1.5 microcuries per week at Cypress Bridge, just upstream from the delta (Figure D-3). On this basis, the annual transport would be about 0.17 ± 0.08 curie per year. These measurements indicate that about half the cesium-137 transported was due to remobilization from the creek floodplain system above L-Reactor.

IV-47| In addition, Hayes (1983e) reported that the water that enters Steel Creek from L-Area and Meyers Branch (the principal tributary of Steel Creek) and as local rainfall contained concentrations of cesium-137 of less than 1 picocurie per liter. However, the measured cesium-137 concentrations at Cypress Bridge averaged about 3.7 ± 0.6 picocuries per liter during the April through August 1983 study period. Hayes contends that a reequilibration process between the water and the cesium in the creekbed and floodplain sediments governs the cesium-137 concentrations, because he could find no correlation during this period between cesium concentration and creek flow rate, or such other variables as suspended solid or tritium concentrations in Steel Creek water or rainfall in the area. Hayes concluded that the creekbed and floodplain sediments could support cesium concentrations as high as about 11 picocuries per liter at equilibrium, and that the lower concentrations (3.7 picocuries per liter) were probably due to insufficient time for the process to reach equilibrium between the water and the cesium-laden sediments. The travel time for water from L-Area to Cypress Bridge is less than 1 day.

D.2.3.2 Savannah River

The concentrations of cesium-137 in the Savannah River have been monitored since 1960. The highest concentrations were measured in the early 1960s as a

result of SRP releases and nuclear weapons test fallout (Figure D-8). Since 1972, concentrations of cesium-137 in the Savannah River have been below the routine detection limit of about 1 picocurie per liter. Recently, special measurements made with high water volume sampling techniques and low level counters show that the 1979-1982 average concentration in the Savannah River was about 0.08 picocurie per liter below SRP and near the limit of detection above SRP (Section 3.7.2). It is estimated that the cobalt-60 concentration in river water during the 1979 to 1982 period averaged about 0.002 picocurie per liter (based on measurements in Steel Creek performed by Hayes and Watts, 1983). TC

Radiocesium and radiocobalt concentrations will be diluted as the flow of the Savannah River increases downstream from SRP, and as these radionuclides are deposited in the river channel and floodplain. Based on river flow records for 1960 to 1969, an increase in flow of 11 percent can be expected between the U.S. Highway 301 bridge (River Mile 118.7) near Millhaven, Georgia, and the Georgia Highway 119 bridge (River Mile 61.5) near Clyo, Georgia. Ratios of drainage areas suggest that river flow will increase by 18 percent between River Mile 118.7 and River Mile 39.2, the location of the intake structure for the Cherokee Hill water treatment plant. Using tritium as a tracer, Hayes (1983a) measured an average 1976-1981 increase in flow of about 20 percent between these two locations. An additional 28 percent reduction in the concentrations of cesium-137 and cobalt-60 can be expected to occur through deposition, sorption and reequilibration of the radionuclides with river channel and floodplain sediments (Hayes and Boni, 1983).

D.2.3.3 Water treatment plants

The North Augusta, South Carolina water treatment plant is about 20 river miles above the SRP. However, there are no known individuals who consume Savannah River water for a distance of about 120 river miles downstream of the SRP. At this distance (River Mile 39.2) and beyond (River Mile 29.0) are the Beaufort-Jasper and Cherokee Hill water treatment plants, respectively. The Beaufort-Jasper water treatment plant pumps water from the river through a 2.4 kilometer long inlet canal that connects to an open canal. This open unlined canal flows 29 kilometers to the water treatment plant (Du Pont, 1983a). The Cherokee Hill water treatment plant pumps from the Savannah River above the U.S. Interstate Highway 95 bridge, and the water is piped about 11 kilometers to the plant (Du Pont, 1983a).

Recent measurement (April through June, 1983) of finished (potable) water indicates that cesium-137 concentrations (from SRP, weapons test fallout, and upstream nuclear reactors) averaged 0.028 picocurie per liter at Beaufort-Jasper and 0.033 picocurie per liter at Cherokee Hill (Kantelo and Milham, 1983). During this monitoring period, the cesium-137 concentrations in the finished water were found to vary inversely with river flow (Kantelo and Milham, 1983). The concentrations of cesium-137 at Beaufort-Jasper are slightly less than those at Cherokee Hill (Hayes and Boni, 1983). The slightly lower concentrations at Beaufort-Jasper result from inflow of local fresh water and deposition, sorption, and reequilibration of cesium-137 with the sediments of the open canal leading to the treatment plant (Hayes and Boni, 1983).

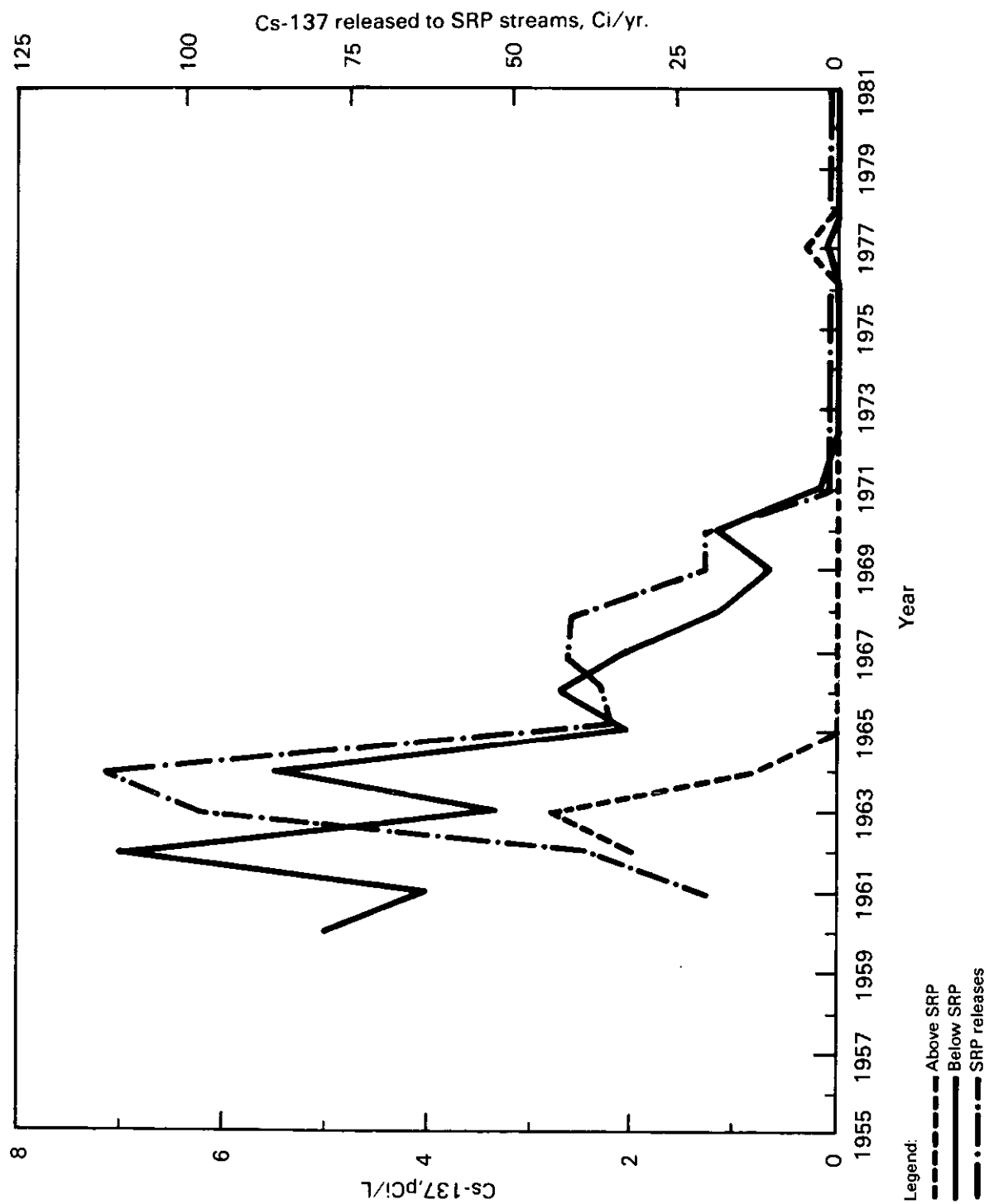


Figure D-8. Cesium-137 concentrations in the Savannah River, 1960-1980.

At North Augusta the concentration of cesium-137 in the finished water averaged 0.006 picocurie per liter, about 5 times less than comparable concentrations in Beaufort-Jasper and Cherokee Hill finished water. Upstream nuclear reactors and nuclear weapons test fallout account for the cesium-137 in the North Augusta finished water (Kantelo and Milham, 1983).

Studies of cobalt-60 in the finished water in these water treatment plants indicate that the concentrations are less than the detection limit of about 0.003 picocurie per liter (Kantelo and Milham, 1983).

Studies made in 1965, when the cesium-137 concentration in river water at the U.S. Highway 301 bridge was 1.47 picocuries per liter, suggest that a concentration reduction of about 48 percent by dilution and by association with river channel and floodplain sediments occurs by the time the water reaches the downstream water supply intakes. The Cherokee Hill water treatment plant removes another 32 percent. Dilution and association with sediments along the open canal and the treatment process at Beaufort-Jasper removes about 50 percent of the cesium-137 from the raw water. Thus, as summarized in Table D-16, the concentration of cesium-137 in the finished water from the water treatment plants is a small fraction of the concentration at the U.S. Highway 301 bridge (Hayes and Boni, 1983).

Table D-16. Cesium-137 concentrations and reduction ratio in the Savannah River and water treatment plants^a

Location	Cs-137 (pCi/ℓ)	Reduction (percent)
North Augusta ^b	0.03	
Highway 301 ^c	1.47	
Highway 17 ^c	0.77	47.6
Cherokee Hill ^b	0.29	80.3
Beaufort-Jasper ^b	0.04	97.3 ^b

^aMeasurements made in 1965; adapted from Hayes and Boni (1983).

^bConcentration in finished (potable) water.

^c"Raw" Savannah River water. Approximate river flow rates of 200 cubic meters per second at Highway 301, and 225 cubic meters per second at Highway 17 at time of cesium-137 sampling.

^dBy the year 2000, the expected reduction factor for Beaufort-Jasper will be 79.3 percent because of planned changes in the intake canal.

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D.3 RADIOCESIUM AND RADIOCOBALT INVENTORY IN STEEL CREEK AND SAVANNAH RIVER SWAMP

A number of different methods were used to calculate the inventory of cesium-137 and cobalt-60 in the Steel Creek system. These inventory estimates are discussed below.

D.3.1 Aerial radiological surveys

Aerial radiological surveys of the Savannah River Plant and the surrounding areas were performed in 1974 and 1979 to determine the surface terrestrial distribution of cesium-137 (Boyns, 1975; Boyns and Smith, 1981). A comparison of the position of the cesium-137 gamma exposure-rate isopleths from these surveys shows that the areas of activity are in the same general locations. Gamma exposure rates in 1979 were lower than those in 1974, which can be explained by the masking effect of higher creek and swamp water levels in 1979 and to a lesser extent by radioactive decay. When adjusted to a common water level, these surveys suggest little or no radiocesium transport (radiocesium associated with the streambed sediments) occurred during the 5-year interval.

Smith et al. (1982) used the 1974 aerial radiological survey data to estimate the mean cesium-137 gamma exposure rates in Steel Creek (Figure D-3). The aurally determined exposure rates were corrected to surface-level rates and to account for the cesium-137 distribution in the soil column. Based on the corrected data, the estimated cesium-137 inventory in Steel Creek (decay corrected to 1981) is 58.1 curies, which may be proportioned approximately as follows (Smith et al., 1981):

<u>Location</u>	<u>Inventory (Ci)</u>
Above Road A	18.4
Below Road A	39.7
Total	58.1

D.3.2 Ground radiological surveys

Smith et al. (1982) performed a ground radiological survey in Steel Creek (Figure D-3) using sodium iodide scintillation counters and stratified random sampling procedures. The cesium-137 gamma exposure rate data were corrected to account for the cesium-137 distribution in the soil column. Based on the corrected data, the estimated cesium-137 inventory (decay corrected to 1981) is

56.9 curies for the Steel Creek floodplain to a depth of 1.0 meter. The approximate portions of this inventory lying above and below Road A are listed below (extrapolated from Smith et al., 1981):

<u>Location</u>	<u>Inventory (Ci)</u>
Above Road A	18.0
Below Road A	<u>38.9</u>
Total	56.9

D.3.3 Soil surveys

Studies of cesium-137 in Steel Creek based on core samples up to 1 meter in length and categorized by soil type, sample depth interval, and creek section (Table D-3, Figure D-3), identified 67.1 curies decay corrected to 1981 between the area above L-Reactor and the delta (Smith et al., 1982). The approximate portions of this inventory lying above and below Road A are listed below:

<u>Location</u>	<u>Inventory (Ci)</u>
Above L-Reactor	9.2
L-Reactor to Road A	24.4
Total Above Road A	<u>33.6</u>

<u>Location</u>	<u>Inventory (Ci)</u>
Road A to Delta	10.4
Delta Area	23.1
Total Below Road A	<u>33.5</u>
Total Steel Creek	67.1

An estimated 8.9 curies is believed to lie onsite in the Savannah River swamp between the Steel Creek delta and the SRP boundary.

Results of soil samples collected in the swamp southeast of Steel Creek in 1974 (Figure D-6) estimated that the radiocesium inventory in the swamp was 25 curies (Marter, 1974); this could have decayed to 21 curies by 1981, assuming no net transport of cesium from the swamp.

D.3.4 Radiocesium inventory by a contaminated area method

Du Pont (1982a) also estimated the cesium-137 inventory in Steel Creek with a contaminated area method, which uses radiological measurements of concentrations in sediments and vegetation, which are integrated over the area and depth. The results of this method yield an inventory estimate of about 75 curies which would have decayed to about 61 curies by 1981. This estimate, detailed below, agrees with the estimates presented in Sections D.3.1, D.3.2, and D.3.3:

<u>Location</u>	<u>Inventory (Ci)</u>
Road A to SCL Bridge	18.0
SCL Bridge to delta	16.2
Delta	<u>26.6</u>
Total	60.8

D.3.5 Radiocesium inventory in vegetation

The cesium-137 inventory in the Steel Creek biotic community is very small. The inventory was made using floodplain areas integrated from USGS floodplain maps, estimates of the biomass inventory (304 grams per square meter; Martin et al., 1977), and analyses of cesium-137 concentrations in vegetation from various stream reaches. Approximately 0.4 curie of the cesium-137 is in the plant community (Du Pont, 1982a). The inventory in the animal community is insignificant (much lower biomass) compared to the plant community.

D.3.6 Radiocesium inventory in water

The amount of cesium-137 in the water of the Steel Creek system at any one time is small, less than 0.001 curie. This estimate is based on the assumption that the water stored in the system is equal to about 1 day's flow. The travel time of water from P-Area to the Cypress Bridge (Figure D-3) is about 0.5 day (Hayes, 1981) and the cesium-137 concentration averages about 4 pCi/l (Ashley and Zeigler, 1978b) (also see Section D.2.3.1).

D.3.7 Summary for cesium-137

Smith et al. (1982) estimated the cesium-137 inventory in Steel creek using gamma exposure rates obtained from aerial and ground surveys and cesium-137 concentrations obtained from soil core measurements. These results are in agreement with the inventory developed by the contaminated area method (Du Pont, 1982a). The inventory of about 67 curies determined from soil core measurements is considered the best estimate. As shown in Figure D-9, this cesium-137 inventory estimate for Steel Creek leaves about 55 curies unexplained.

This unaccounted for cesium-137 is within the error limits of the estimated inventory. The unexplained cesium-137 might be caused by:

Less radiocesium released than indicated in Table D-1.

A cesium-134-to-cesium-137 ratio greater than 1:20.

Cesium-137 deposited in the Savannah River between the mouth of Steel Creek and the U.S. Highway 301 bridge.

More cesium-137 from Steel Creek transported past the U.S. Highway 301 bridge than indicated by the measurements.

More cesium-137 below depths of 1 meter than indicated by Figure D-4.

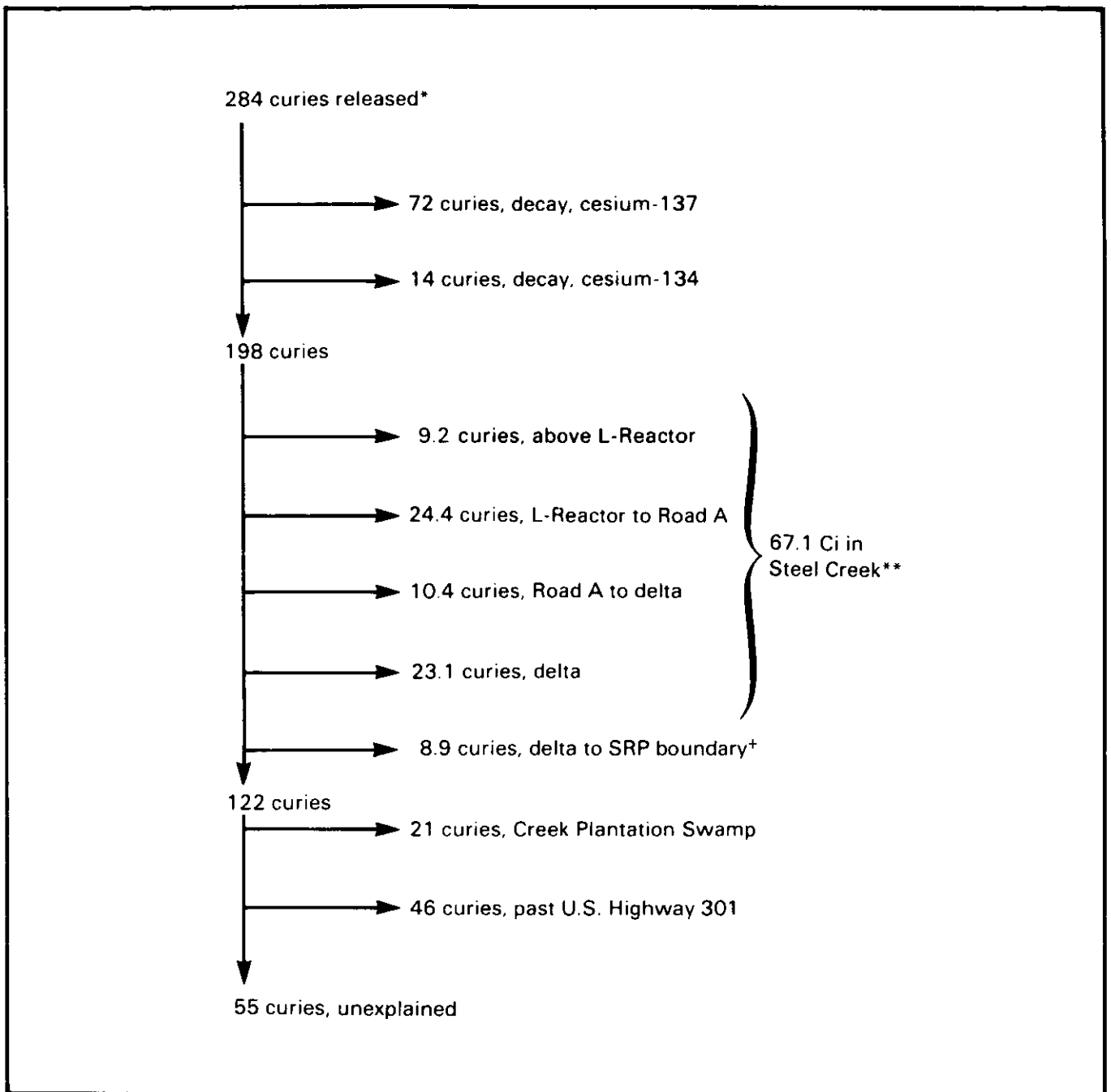
D.3.8 Radiocobalt inventory

The current radiocobalt inventory in Steel Creek has been bounded by two values, 2.1 and 4.6 curies, and calculated according to the following methods, respectively, (1) assuming no transport of cobalt from the creek system and decay correcting to 1981, and by (2) conservatively assuming that cobalt behaves in a manner similar to cesium such that the inventory is reduced by a factor of .068, the ratio of cobalt-60 to cesium-137 in the sediments of the Steel Creek system.

D.4 REMOBILIZATION OF RADIOCESIUM AND RADIOCOBALT

A portion of the cesium-137 and cobalt-60 inventory that is currently in the Steel Creek channel and floodplain (Figure D-9) will be remobilized and transported off the plant site when the direct discharge of thermal effluents to Steel Creek is resumed after the restart of L-Reactor at temperatures as high as 75°C near the outfall canal and at discharge rates of about 11 cubic meters per second (reference case). This remobilization of cesium-137 and cobalt-60 will augment the small amount that is currently being transported from the creek.

Using the reference case, the quantities of cesium-137 (and cobalt-60) transported from Steel Creek to the Savannah River and to offsite portions of the swamp (Creek Plantation Swamp) as the result of L-Reactor operations are reestimated below, using 1976 monitoring data, a new set of data for 1982 on radionuclide transport in Steel Creek, and the historic flooding record for the swamp (Du Pont, 1982a, 1983a; Langley and Marter, 1973). Section 4.4.2 contains estimates of cesium-137 remobilization and transport for each alternative cooling-water system (also see Section D.4.4). TC



*Released to Steel Creek during 1955-1980.

**Based on soil core measurements.

+ Estimated

Figure D-9. Cesium-137 mass balance in Steel Creek in 1981 based on soil core and river measurements and decay.

The following field measurements in Steel Creek provided data that were used in the transport analyses:

- In June 1976, a study was performed to observe the effect of a month-long diversion from P-Reactor Area (to permit inspection of Par Pond dam) of about 2.5 cubic meters per second of hot water (about 70°C at the discharge point) on desorption of cesium-137 from the sediments. The cesium-137 transport near Road A peaked at about 3.2 mCi/day within 2 weeks and returned exponentially to normal levels in about 3 months (Du Pont, 1982a). These data were supplemented by laboratory hot water desorption experiments (Du Pont, 1982a).
- In the spring of 1982, a study was performed to observe the transport of cesium-137 and cobalt-60 during testing of the L-Reactor secondary cooling-water system using Savannah River water that was discharged at near-ambient temperatures and at flow rates up to about 6 cubic meters per second. Measurement of creek flow and concentration of cesium-137 in water samples during these tests were used to reestimate the sediment-water transport values presented in Du Pont (1982a). Similar measurements were used to predict the sediment-water transport of cobalt-60 that is likely to occur when L-Reactor cooling-water discharges are resumed (Hayes, 1983b; Hayes and Watts, 1983).

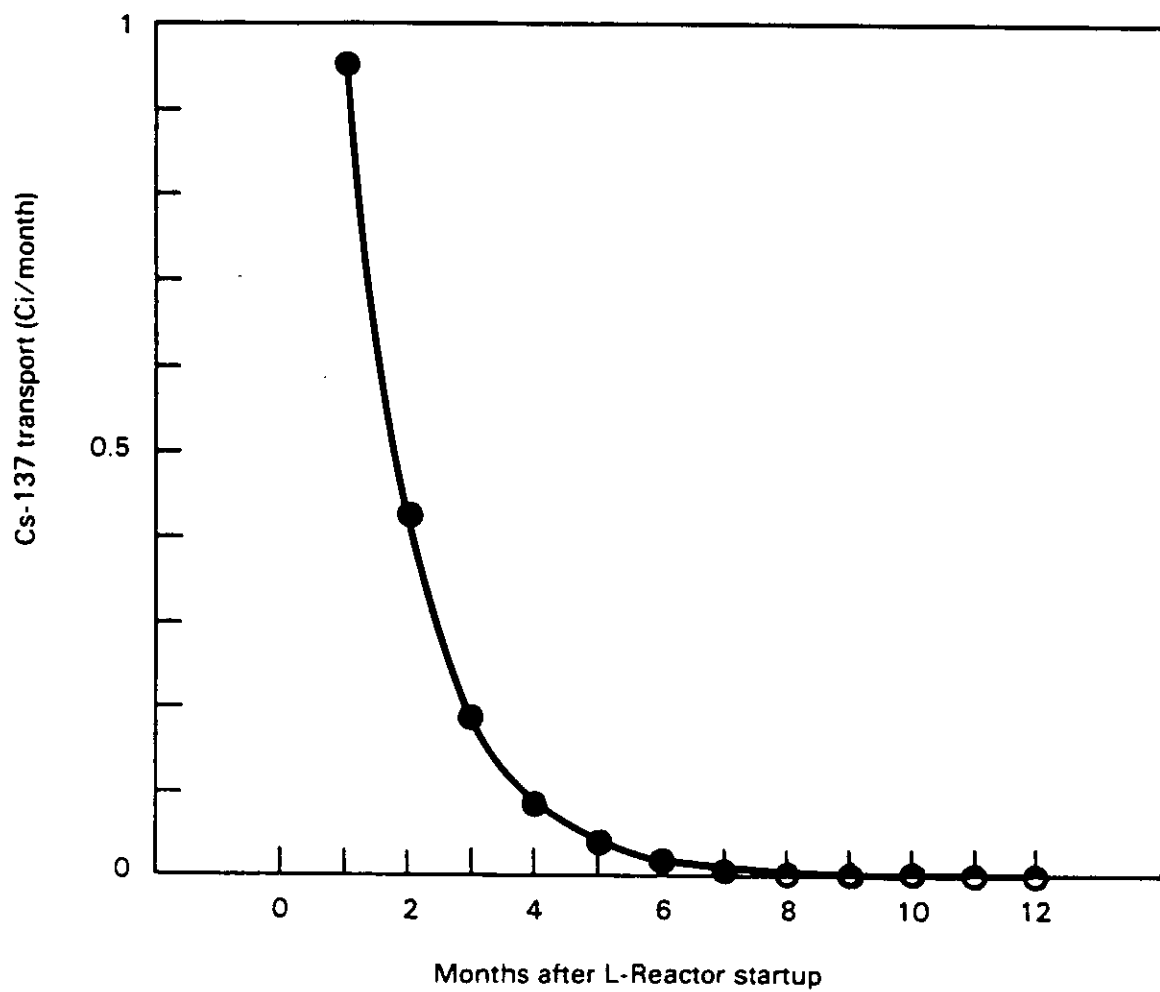
D.4.1 Desorptive transport

For the reference case, hot-water desorption of cesium-137 and cobalt-60 from the sediments in the Steel Creek system will occur following the resumption of L-Reactor operation. From early June 1976 until the end of that month, about 2.5 cubic meters per second of heated water, discharged at approximately 70°C, was diverted to Steel Creek from P-Reactor. The cesium-137 concentration at Cypress Bridge (Figure D-3) peaked within 2 weeks after the start of the diversion and decreased exponentially to a background level in about 3 months (Du Pont, 1982a). To estimate the heated water cesium-137 transport, the Cypress Bridge data (Figure D-10) were fitted with an exponential function and integrated to give monthly transport values.

A correlation coefficient of 0.94 was calculated using an exponential representation of the data. A laboratory experiment (Du Pont, 1982a) with sediments from Steel Creek confirmed that higher water temperatures extract more cesium-137 than water at ambient temperatures.

These analyses indicate that the transport in the first year for the reference case would be about 1.7 curies due to cesium-137 being desorbed from the sediments.

Hot water desorption experiments conducted in the laboratory to determine the desorption of cesium-137 from sediments also showed the desorption of small amounts of cobalt-60 (Table D-17) (Du Pont, 1982a; Hayes and Watts, 1983). The cobalt-60 to cesium-137 ratio of desorbed activity averaged 0.056. An estimate of the amount of cobalt-60 that will be desorbed during the first year of L-Reactor operation for the reference case was made by multiplying the 1.7



Source: Du Pont (1982a).

Figure D-10. Transport of cesium-137 from hot-water desorption of cesium-137 from Steel Creek sediments.

curies of cesium-137 that is expected to be desorbed by the laboratory-determined cobalt-60/cesium-137 ratio, 0.056. This calculation indicates that about 95.2 mCi/yr or 0.26 mCi/day of the cobalt-60 is expected to be desorbed from the sediments in the first year. No additional desorption is expected the second year.

Table D-17. Cs-137 and Co-60 desorption from sediments during a laboratory experiment^a

Water Temperature (°C)	Activity Desorbed (pCi/l)		
	Co-60	Cs-137	$\frac{\text{Co-60}}{\text{Cs-137}}$
72	20.4	458	0.045
52	25.4	288	0.088
42	14.2	384	0.037
22	16.5	314	0.053
Average ratio = 0.056 ± 0.023			

^aAdapted from Du Pont, 1982a, Appendix I.

D.4.2 Transport in biota

SRP routinely monitors vegetation in the Steel Creek corridor for radionuclides. Even though cesium-137 is routinely detected in the vegetation, cobalt-60 is not. The limit of detection for cobalt-60 is about 5 pCi/g.

About 0.4 ± 0.2 curie of cesium-137 is tied up in the biota on the Steel Creek floodplain. The reference-case discharge, principally the result of high flow rates and fluctuating water levels (related to reactor operation about 65 percent of the year), would be expected to kill this biota in the first year of L-Reactor operation and to transport the isotope off the site.

TC

D.4.3 Sediment-water transport

D.4.3.1 Cesium-137

The initial (1981) estimates of the expected cesium-137 transport in Steel Creek following L-Reactor restart using the direct discharge of cooling water to Steel Creek (reference case) are presented in Du Pont (1982a). The cesium-137 transport process was divided into three elements: coupled suspended sediment-water (7.7 ± 4.4 curies first year, 7.2 curies second year), hot water desorption (1.7 ± 0.2 curies; Section D.4.1, above), and biota loss (0.4 ± 0.2 curies; Section D.4.2, above). In this manner, total cesium-137 transport was estimated at 9.8 curies for the first year and 7.2 curies for the second year, with a 20-percent-per-year decrease thereafter. To improve these estimates of cesium-137

remobilization in the Steel Creek system, cesium-137 transport studies were made during secondary cooling-water system tests using ambient river water from February to April 1982. These tests included flows as high as about 6 cubic meters per second, about one-half of full reactor cooling-water flow (Hayes, 1983b; Du Pont, 1983a).

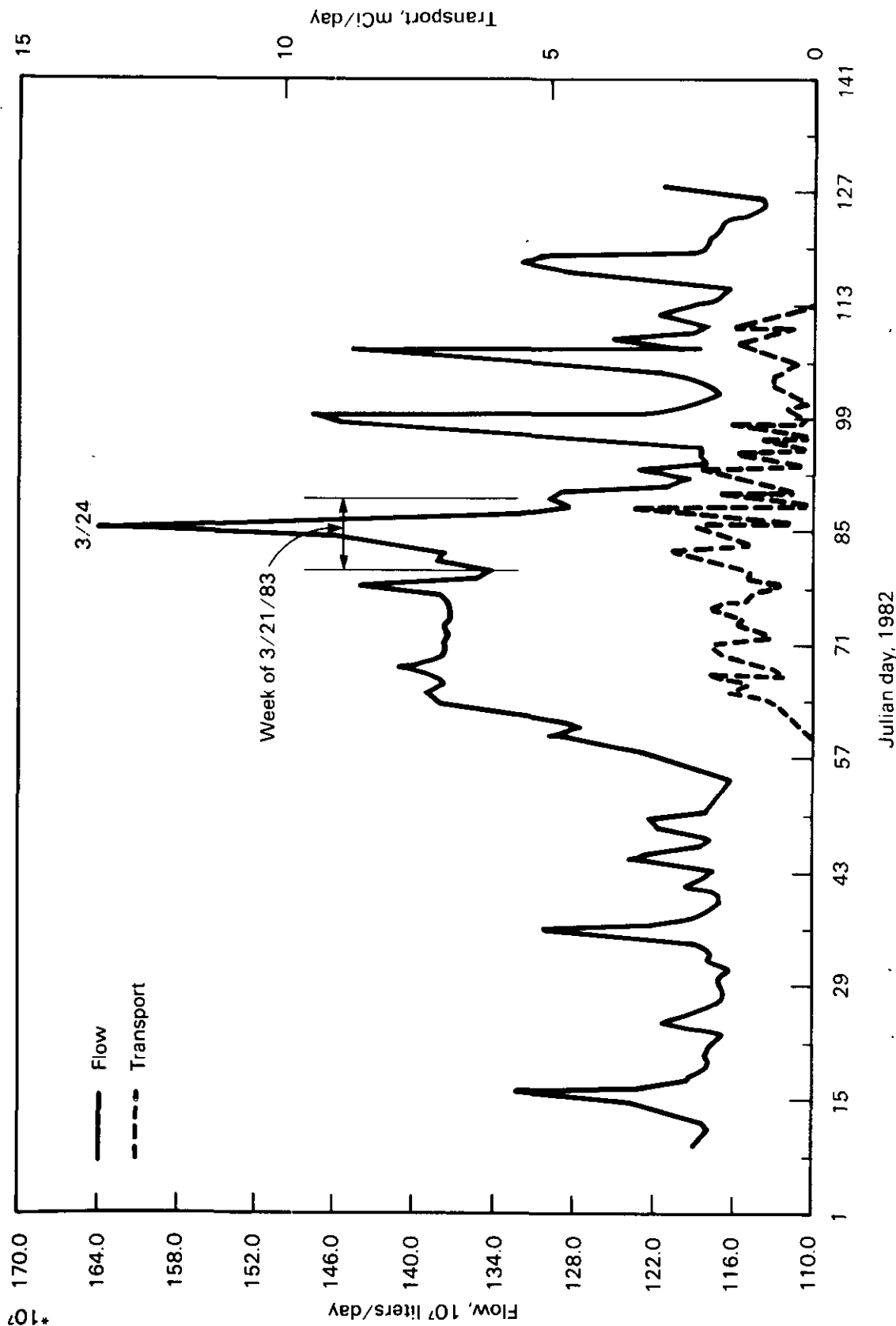
Average flow rates required to estimate total cesium-137 transport (flow rate times concentration) were obtained by calculating noon-to-noon average flow using data sampled every 15 minutes from the U.S. Geologic Survey-maintained gaging station at the Cypress Bridge upstream of the creek mouth (Figure D-3). Composite water samples were also obtained on a noon-to-noon schedule; however, they were collected at the mouth of Steel Creek. Because Pen Branch combines with Steel Creek in the swamp before discharging to the Savannah River, the creek flow values measured at Cypress Bridge were increased by 12.7 cubic meters per second to obtain the correct flow at the mouth of Steel Creek. Flow rates in Steel Creek varied during the test period, depending on the specific test of the secondary cooling water system being conducted (see Figure D-11).

As shown in Figure D-11 and Table D-18, the test period most similar to the reference case conditions expected during resumed L-Reactor operation occurred during the week of March 21, 1982 (Julian day 80). During this week (on March 24, 1982), the average daily flow reached 6.2 cubic meters per second and averaged 3.5 cubic meters per second for the week. This average weekly flow exceeded any previous weekly discharge of cooling water flow since L-Reactor was shut down in 1968, although flows of this magnitude have occurred as the result of heavy rainstorms (see Section 3.4.1).

Increases in total cesium-137 concentrations (with suspended solids and in solution) at the mouth of Steel Creek lagged the increase in pump test flow (Table D-18). The highest cesium-137 concentration, 2.7 pCi/l, occurred on March 28, 1982, about 3 days after the flow decreased to about 2.1 cubic meters per second from the peak flow of 6.2 cubic meters per second. This concentration is probably the result of water draining off the back areas of the floodplain and into the creek. Water in the back areas would have longer residence times and the sediments have higher concentrations of cesium-137 (Figure D-5); thus, the water draining from these areas could accumulate higher cesium-137 concentrations.

The average daily cesium-137 transport during the period of highest flow, March 21-28, 1982, was 1.96 ± 1.53 mCi and at an average flow of 3.5 cubic meters per second (flow measured at Cypress Bridge). Hayes (1983b) used this data to reestimate the transport of cesium-137 from the mouth of Steel Creek. His new estimate for the sediment-water transport during the first and second years of resumed reactor operation is 2.3 ± 1.8 curies per year (1.96×10^{-3} curies per day $\times [11 \text{ cms}/3.5 \text{ cms}] \times 365.25 \text{ days/year} = 2.3 \text{ Ci/yr}$).

This transport estimate is supported by more recent measurements (Hayes, 1983e). Hayes believes that the concentrations of cesium-137 in Steel Creek water are governed by a reequilibration process between the water and the cesium in the creekbed and floodplain sediments (see Section D.2.3.1). During the April through August 1983 study period, the cesium-137 concentration at Cypress Bridge averaged 3.7 picocuries per liter on a weekly basis. From this value and a cooling-water discharge from the heat exchangers of about 11 cubic meters per second, the estimated sediment-water transport during the first and second years



Note: See Table D-16 for data listing.

Source: Hayes (1983b).

Figure D-11. Daily average discharge and cesium-137 transport at Steel Creek mouth from January 8 to May 6, 1982.

Table D-18. Daily Cs-137 concentrations, transport and creek flow at mouth of Steel Creek^a

Calendar date	Julian date	Cs-137 (pCi/l)	Cs-137 (mCi/day)	Flow (m ³ /day)
03/01/82	60	0.1	0.129	1,293,600
03/05/82	64	0.6	0.826	1,376,900
03/06/82	65	1.2	1.661	1,384,250
03/07/82	66	0.9	1.270	1,411,200
03/08/82	67	1.4	1.935	1,381,800
03/09/82	68	0.6	0.826	1,376,900
03/10/82	69	1.1	1.517	1,379,350
03/11/82	70	1.4	1.924	1,374,450
03/12/82	71	1.4	1.931	1,379,350
03/13/82	72	0.6	0.825	1,374,450
03/14/82	73	1.1	1.512	1,374,450
03/15/82	74	1.0	1.377	1,376,900
03/16/82	75	1.4	1.931	1,379,350
03/17/82	76	1.2	1.729	1,440,600
03/18/82	77	0.9	1.217	1,352,400
03/19/82	78	0.5	0.671	1,342,600
03/20/82	79	1.0	1.384	1,384,250
03/21/82	80	0.9	1.249	1,376,900
03/22/82	81	1.5	2.124	1,416,100
03/23/82	82	1.9	2.774	1,460,200
03/24/82	83	0.9	1.473	1,636,600
03/25/82	84	1.0	1.428	1,428,350
03/26/82	85	1.6	2.120	1,325,450
03/27/82	86	0.8	1.027	1,283,800
03/28/82	87	2.7	3.513	1,300,950
03/29/82	88	0.3	0.387	1,291,150
03/30/82	89	1.4	1.701	1,215,200
03/31/82	90	0.4	0.477	1,193,150
04/01/82	91	1.1	1.358	1,234,800
04/02/82	92	1.8	2.130	1,183,350
04/03/82	93	0.6	0.712	1,188,250
04/04/82	94	1.1	1.304	1,185,800
04/05/82	95	0.4	0.517	1,293,600
04/06/82	96	0.8	1.162	1,452,850
04/08/82	98	1.1	1.350	1,227,450
04/09/82	99	0.1	0.120	1,195,600
04/10/82	100	0.5	0.589	1,178,450
04/11/82	101	0.1	0.117	1,173,550
04/13/82	103	0.7	0.852	1,217,650
04/14/82	104	0.6	0.808	1,347,500
04/16/82	106	0.4	0.476	1,190,700
04/18/82	108	1.2	1.438	1,198,050
04/20/82	110	1.3	1.586	1,220,100
04/22/82	112	0.2	0.236	1,178,450

^aAdapted from Hayes, 1983b. Cesium-137 values are the sum of the suspended solid fraction and the dissolved fraction. See Figure D-11.

of resumed reactor operation (under the reference case) is 1.3 curies per year ($11 \text{ cubic meters per second} \times 1000 \text{ liters per cubic meter} \times 86,400 \text{ seconds per day} \times 365.25 \text{ days per year} \times 3.7 \times 10^{-12} \text{ curies per liter} = 1.3 \text{ curies per year}$). If the upper equilibrium limit of 11 picocuries per liter (Hayes, 1983e) is used, the transport estimate becomes 3.8 curies per year, which is within the estimate of 2.3 ± 1.8 curies per year (Hayes, 1983b) described in the preceding paragraph. The travel time from the L-Reactor outfall to the Steel Creek delta, about 1 day, is apparently too short to develop the upper concentration equilibrium limit.

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D.4.3.2 Cobalt-60

Radiocobalt was detected in only four of the suspended sediment samples obtained during the flow tests of the secondary cooling-water system. In contrast, cesium-137 was detected in nearly all of the 250 samples. Because of the limited number of positive samples from the flow test, the expected cobalt-60 sediment-water transport was conservatively estimated by assuming that the cobalt-60 in the sediments would be transported in a manner similar to cesium-137. The ratio of cobalt-60 to cesium-137 in the sediments of the Steel Creek system is about 0.068 (Table D-6).

On the basis of the flow test data, a weekly maximum of about 0.56 mCi/day- m^3 /sec of cesium-137 was remobilized from Steel Creek. Thus, the expected cobalt-60 transport from sediment sources in Steel Creek, as determined by Hayes and Watts (1983) is 0.43 mCi/day or 0.16 curie per year ($0.56 \times 10^{-3} \text{ Ci/day-}\text{m}^3\text{/sec} \times 0.068 \times 11 \text{ cms} \times 365.25 \text{ days/year} = 0.16 \text{ Ci/yr}$).

D.4.4 Summary of remobilization estimates

For the reference case, the total amount of cesium-137 estimated to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation is 4.4 ± 2.2 curies. This value is the sum of three transport estimates: 1.7 ± 0.2 by desorptive transport, 0.4 ± 0.2 curie transport in biota, and 2.3 ± 1.8 curies suspended sediment-water transport. In the second year it is anticipated that this value will be reduced to 2.3 ± 1.8 curies. Thereafter, a 20 percent reduction in transport per year is assumed. Thus, after 10 years of resumed operation, approximately 14.4 curies of cesium-137 will have been transported to the Savannah River swamp system (Hayes, 1983b).

The 2.1 curie decrease from the first to the second year is based on the assumption that the hot cooling water will no longer desorb cesium-137 from the creekbed and floodplain sediments and that there is no more vegetation to contribute cesium-137. It is also noted that the sediment-water transport estimate presented here is substantially less than initially estimated (Du Pont, 1982a); however, the original estimates of transport resulting from hot water desorption and from cesium-137 in the vegetation remain unchanged (see Section D.4.3.1).

TC The amount of cesium-137 remobilized and transported to the Savannah River on an annual basis was estimated for each alternative cooling-water systems involving flowing streams (see Section 4.4.2) by applying the following equation:

$$Cs_{out} = 2.3F + 0.4F + 1.7(T/75^{\circ}C), \text{ in curies per year}$$

where F is the cooling-water flow normalized to the flow from the reference case, and T is the temperature ($^{\circ}C$) of the water discharged from the cooling-water system to Steel Creek during periods of severe summer meteorological conditions. This equation accounts for the three major aspects of cesium-137 remobilization and transport--the first term accounts for sediment-water transport, the second term is for biota (principally vegetation), and the third term is for hot-water desorption. For the reference case, $F = 1$ and $T = 75^{\circ}C$, and $CS_{out} = 4.4$ curies per year. This equation is believed to provide conservative results because, when the summer ambient conditions (0.62 cubic meter per second creek flow at L-Reactor with a water temperature of $28^{\circ}C$) are used as input parameters, the calculated cesium-137 transport is 0.65 curie per year, about three times the measured value.

The total amount of cobalt-60 estimated to be remobilized and transported from Steel Creek during the first year of resumed L-Reactor operation is estimated to be at most 0.25 ± 0.13 curie. This total is composed of a 0.16 curie per year fraction associated with sediment-water transport and a 0.09 curie per year fraction associated with desorptive transport. During the second year, up to 0.14 ± 0.10 curie will be transported in association with the suspended sediments ($0.16 \text{ Ci/yr} \times 0.876 \text{ decay factor} = 0.14 \text{ Ci/yr}$; Hayes and Watts, 1983). Approximately 0.6 curie of cobalt-60 will be transported to the Savannah River swamp system during the first 10 years of resumed L-Reactor operation.

Tables D-19 and D-20 compare the current cesium-137 and cobalt-60 transport values with the estimated values for the first, second, and tenth years after resumption of L-Reactor operation. Maximum concentrations of cesium-137 and cobalt-60 1.5 river miles below Steel Creek, the point of complete mixing of Steel Creek and river water, are predicted to be $1/425$ and $1/3300$ of the EPA drinking-water standard, respectively. Concentrations in finished water from the Beaufort-Jasper and Cherokee Hill water treatment plants are predicted to be very small fractions of these drinking-water standards.

D.4.5 Accumulation of cesium-137 in Creek Plantation Swamp

The flooding of the SRP and Creek Plantation swamps at river stages above 27.7 meters above mean sea level (about 440 cubic meters per second) will cause the flow from Steel Creek to be diverted from the Savannah River into the swamp paralleling the river. In the past, this diversion has caused cesium-137 to be deposited in Creek Plantation Swamp (Figure D-6) and other areas. Radiological surveys showed that the cesium-137 was in a relatively narrow band on the bank-side edge of the Creek Plantation floodplain. Using sediment measurements, about 21 curies of cesium-137 are currently estimated to be present in the Creek Plantation Swamp.

Table D-19. Estimated cesium-137 remobilization from Steel Creek compared with current transport values^a

Location	River Mile	Inventory transported (Ci/yr)				Concentration in water (pCi/ℓ)			
		Current values	After restart			Current values	After restart		
			1st year	2nd year	10th year		1st year	2nd year	10th year
Steel Creek mouth Savannah River at 1.5 river miles below Steel Creek	141.6	0.25	4.4	2.3	0.4	5.3	11.15	5.80	1.01
Hwy 301 bridge	140.1	0.41 ^b	4.4	2.3	0.4	0.04 ^b	0.47	0.25	0.04
Hwy 17 bridge	118.7	0.39 ^b	4.3	2.2	0.4	0.04 ^b	0.44	0.23	0.04
	21.4	0.20 ^b	2.7	1.4	0.2	0.02 ^b	0.23	0.12	0.02
WATER TREATMENT PLANTS									
Finished water									
Beaufort-Jasper	39.2	--	--	--	--	0.028	0.01	<0.01	<<0.01
Cherokee Hill	29.0	--	--	--	--	0.033	0.09	0.05	<0.01
EPA interim primary drinking water standard	--	--	--	--	--	200	200	200	200

^aBased on mean transportation estimates made by Hayes (1983b) and Hayes and Watts (1983), and data presented in Table D-16, and average flow rates in the Savannah River at locations indicated. Estimates of concentration and transport for 1st, 2nd and 10th year only represent the contribution resulting from the remobilization of cesium-137 in Steel Creek by resumed operation of L-Reactor (reference case). No alterations of existing water treatment plant systems were assumed.

^b1979-1982 average concentration measured at the Hwy. 301 bridge was 0.04 picocurie per liter; other values derived using appropriate flow rates and reduction factors.

Table D-20. Estimated cobalt-60 remobilization from Steel Creek compared with current transport values^a

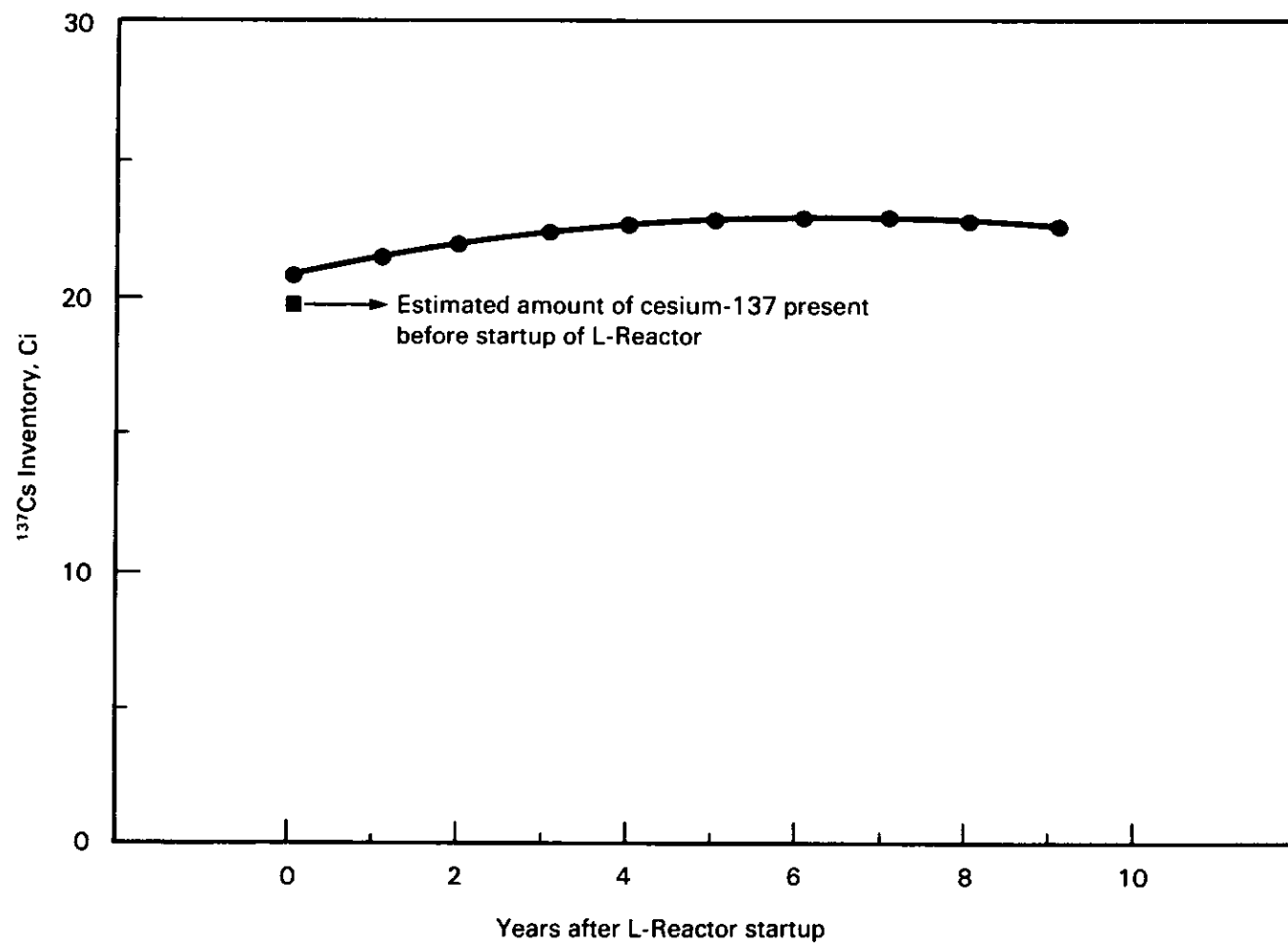
Location	River Mile	Inventory transported (Ci/yr)				Concentration in water (pCi/l)			
		Current values	After restart			Current values	After restart		
			1st year	2nd year	10th year		1st year	2nd year	10th year
Steel Creek mouth	141.6	0.02 ^b	0.25	0.14	<0.01	0.3 ^b	0.63	0.35	0.02
Savannah River at 1.5 river miles below Steel Creek	140.1	0.02 ^b	0.25	0.14	<0.01	<<0.01 ^b	0.03	0.02	<<0.01
Hwy 301 bridge	118.7	0.02 ^b	0.24	0.14	<0.01	<<0.01 ^b	0.03	0.02	<<0.01
Hwy 17 bridge	21.4	0.01 ^b	0.15	0.09	<<0.01	<<0.01 ^b	0.02	<0.02	<<0.01
WATER TREATMENT PLANTS									
Finished water									
Beaufort-Jasper	39.2	--	--	--	--	<0.003 ^c	0.02	<0.02	<<0.001
Cherokee Hill	29.0	--	--	--	--	<0.003 ^c	0.02	<0.02	<<0.001
EPA interim primary drinking water standard	--	--	--	--	--	100	100	100	100

^aBased on mean transportation estimates made by Hayes (1983b) and Hayes and Watts (1983), and average flow rates in the Savannah River at locations indicated. Estimates of concentration and transport for 1st, 2nd and 10th year only represent the contribution resulting from the remobilization of cobalt-60 in Steel Creek by resumed operation of L-Reactor (reference case). No credit is taken for removal of cobalt-60 by the water treatment process.

^bEstimated on the basis of 0.06 times the value for cesium-137.

^cBased on Kantelo and Milham (1983).

Cesium-137 is expected to be deposited again in Creek Plantation Swamp during the first 10 years of operation of L-Reactor (reference case) as a result of river flooding and the transport of cesium-137 from Steel Creek. The maximum inventory estimate, corrected for radioactive decay, will be about 23 curies about 6 years after resumed L-Reactor operation (Figure D-12).



Adapted from Du Pont (1982a).

Figure D-12. Increase in cesium-137 on the Creek Plantation Swamp.

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APPENDIX E

ARCHEOLOGICAL AND HISTORIC RESOURCES

In accordance with the National Environmental Policy Act of 1969, Executive Order 11593, the National Historic Preservation Act of 1966, as amended in 1980, and the Archeological and Historic Preservation Act of 1974, archeological and historic surveys were conducted for the resumption of L-Reactor operation. Because no major earthwork is to be undertaken at the L-Reactor site, the surveys were focused on the Steel Creek terrace and floodplain system into which L-Reactor cooling water is planned to be discharged.

This appendix describes the results of the survey performed on the Steel Creek terrace and floodplain system for the L-Reactor operation reference case (direct discharge). In addition, this appendix contains tables that list sites contained in the National Register of Historic Places in the six-county area (Figure 3-4) near Savannah River Plant (SRP). Additional surveys and mitigation have been performed or are in progress; these are described in Appendix L.

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E.1 STEEL CREEK ARCHEOLOGICAL AND HISTORIC RESOURCES

The archeological and historic survey of the Steel Creek terrace and floodplain system below the L-Reactor area was conducted during January and February of 1981 (Hanson et al., 1981). The purpose of the survey was to identify all archeological and historic resources in the potentially affected area, and to determine if identified sites would be affected by increased flow in Steel Creek. The following subsections describe a subsistence model for the prehistoric occupation of the Steel Creek area, a summary of historical activities of the general area, the survey that was performed, and the results of the survey.

E.1.1 Settlement-subsistence model

The variability in the topography, hydrology, elevation, soils, and biota of the Steel Creek watershed was used to construct a settlement-subsistence model for prehistoric times (Figure E-1). The watershed has been divided into four zones, each having characteristic resources for prehistoric man. Two zones--the Savannah River swamp (Zone IV) and the tributary/bottomlands (Zone III)--would have been inhospitable for long-term settlement due to their excessive moisture and poorly drained soils. However, due to the extremely high productivity of these zones, they are expected to have been seasonally exploited for their aquatic resources. Thus, sites located in these zones would represent limited activities, and more permanent residential sites would be elsewhere.

The zone with the greatest probability for providing more permanent base-camp and habitation sites is the mesic terrace (Zone II), just above the tributary/bottomland zone. The mesic terrace is highly productive in flora and fauna during the spring, summer, and fall. Its soils and topography provide dry

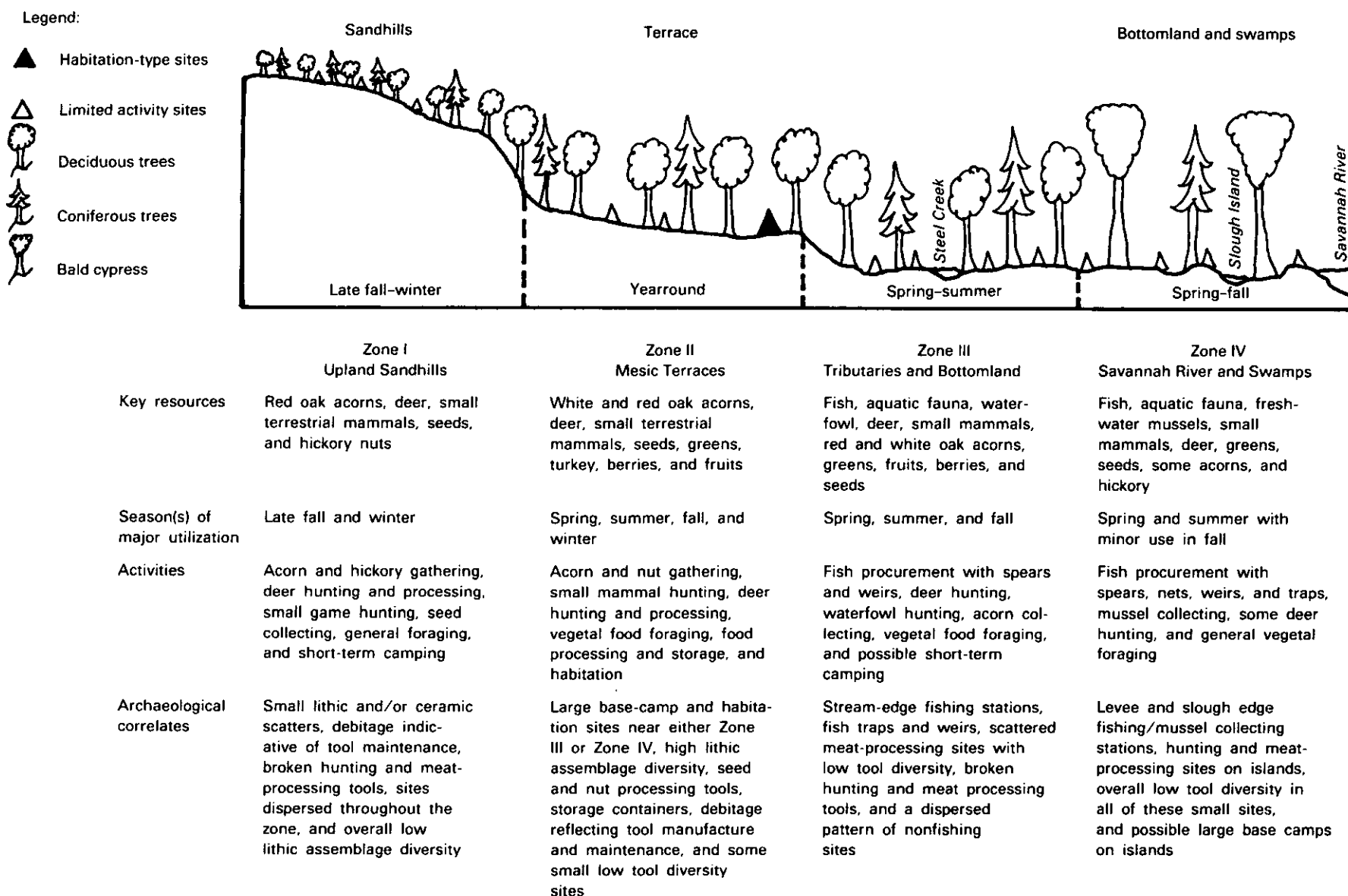


Figure E-1. General settlement-subsistence model for Steel Creek watershed.

and protected areas for dwellings. All areas in this zone are within 1 kilometer of permanent water sources.

For the most part, resources in the upland zone (Zone I) are available in their highest densities during the late fall and winter. The limiting factor in this zone is water, which occurs only in small springs and intermittent streams. Sites in this zone would be expected to represent limited activity, the primary activities being hunting and meat processing. Contributions to the archeological record would be limited to broken or exhausted tools related to these activities.

E.1.2 Prehistoric time periods

Early Archaic (9500 to 7500 B.C.) and Middle Archaic (7500 to 3000 B.C.) components found at three sites indicate a substantial early occupation in the Steel Creek watershed. The data collected indicate a subsistence strategy relying on the seasonal use of a great variety of resources scattered over a number of the settlement-subsistence zones, including an intensive use of the upland area of Savannah River Plant. This environmental diversification is accompanied by a gradual diversification of tool assemblage needed to accomplish various procurement tasks.

The predominant era of occupation, however, occurred during the Late Archaic (3000 to 1000 B.C.) and Early Woodland (1000 B.C. to A.D. 1), as evidenced by data collected at 10 sites. The data indicate subsistence strategy, but with an increased emphasis on riverine resources. Artifactual assemblages were much more diverse than those from previous periods, including for the first time a large number of ground stone tools, grinding tools, and both ceramic and steatite vessels. Toward the Early Woodland period there was a gradual lessening of reliance on floodplain resources. Sites on Savannah River Plant seem to be evenly distributed between riverine and upland areas but reflect an increased use of uplands during this era.

Following the Early Woodland period, the occupation in the watershed appears to be reduced, suggested by a smaller number of Middle and Late Woodland components. These sites were restricted to the upland zone.

Finally, the survey established only one Mississippian (A.D. 1000 to A.D. 1700) component in the watershed, in the upland zone, which suggests a largely reduced use of the area during the most recent prehistoric period. The data collected indicated an even greater reliance on the upland zone for resources.

E.1.3 Steel Creek watershed survey

The archeological and historical survey study area consisted of the Steel Creek 100-year floodplain. Two teams of archeologists traversed a stretch of Steel Creek approximately 13 kilometers long and 300 meters wide, inspecting 4-square-meter plots of the ground surface every 5 meters along the creek. The study area was inspected by raking the ground surface in a systematic manner.

When a site was located, random or systematic rake tests, as appropriate, determined the extent of the site. If a site was within 125 meters of Steel Creek, subsurface testing was performed to determine the nature of the site. Data and artifacts were recovered from 18 discrete locations in the study area (Figure E-2 and Table E-1).

E.1.4 Conclusions

The sites located during the survey were divided into three groups to evaluate their eligibility for nomination to the National Register (36 CFR 63.3). The following criteria were used: (1) those sites that are not significant; (2) those that have the potential for being significant; and (3) those that are significant. Sites characterized as significant have unique and sufficient content, integrity, and scientific importance to warrant their eligibility to the National Register; their content, integrity, and importance would suffer adverse effects from any man-caused activity that alters or destroys the immediate environment.

Ten of the sites located during the survey were not considered significant (Table E-2). These sites are prehistoric but are either lacking in integrity or limited in archeological content.

Seven of the sites located during the survey were considered to be potentially significant (Table E-2). Three of these are prehistoric with well-preserved archeological content. Each has the potential to give valuable scientific information about Archaic and Woodland adaptations and possibly about the development of ceramic technology in the area. These three sites are situated well beyond the area of potential impact from the increased water flow down Steel Creek. These three prehistoric sites have been determined not to be eligible for nomination to the National Register. The four other sites are historic features, three mill dams and a roadway, all situated on Steel Creek. These features have been weathered and partially destroyed by pre-SRP activities. The actual wooden mill structures are no longer standing, but the dams are relatively intact and well preserved. The bridge portion of the roadway that spanned Steel Creek is in ruins, but the earthen approaches are intact. These four sites are indicative of the pre-Civil War era and have the potential to yield information regarding the economy and transportation systems of the area. They also have been subjected to high water flow conditions, similar to the conditions anticipated with L-Reactor operations; they show no sign of adverse effects as a result of those conditions. In July 1982, DOE requested the concurrence of the Keeper of the National Register regarding these sites' eligibility for nomination to the National Register. The Keeper of the National Register concurred in the eligibility of these four sites for inclusion in the National Register.

One prehistoric site, located at the confluence of Steel Creek and Meyers Branch, was considered significant in terms of the National Register criteria. Although other sites contain similar artifactual data, this site's rich and diverse archeological deposit has the potential to provide valuable knowledge regarding the changes in technology and culture of the uninterrupted occupation from the Early Archaic through the Mississippian periods. Therefore, this site is considered a significant prehistoric resource. Aerial photographic studies

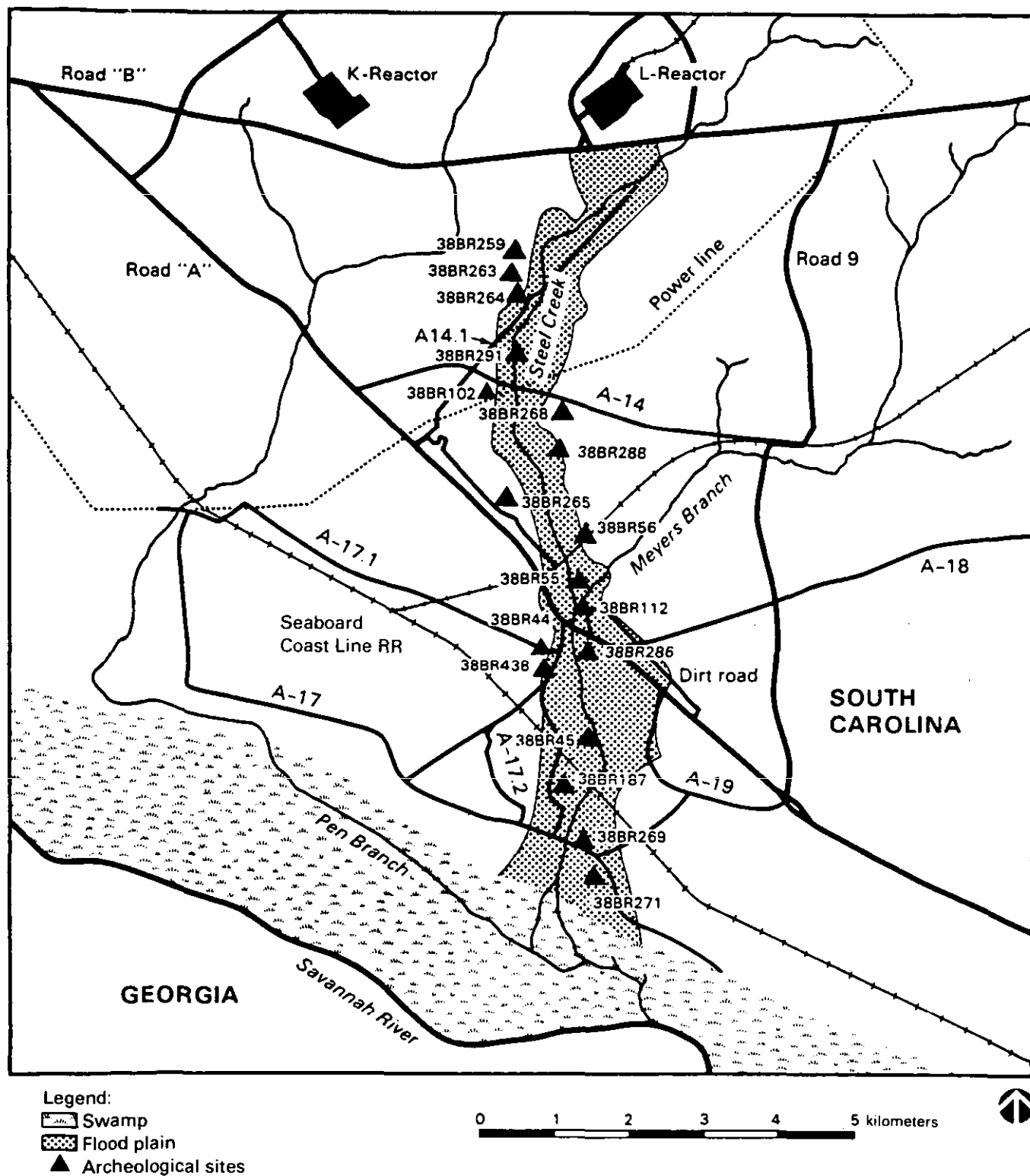


Figure E-2. General map of the survey area indicating site location.

Table E-1. Steel Creek archeological sites

Site number	Approximate location	Approximate size (m)	Prehistoric occupation ^a	Historic occupation	Remarks
38BR438	200 m west of floodplain; along Rd A-17 285 m south of Rd A-17.1	150 x 300	Middle and Late Archaic; Woodland	19th and 20th centuries	Repeated prehistoric occupation on a seasonal basis with habitation; no subsurface exploration; potentially significant.
38BR44	75 m west of floodplain; 100 m south of Rd A-17/A-17.1 junction	50 x 100	Early to Late Archaic	1780-1840 to 1930	No subsurface exploration except for material exposed in road cut to depth of 50 cm; site of preferred occupation.
38BR45	100 m west of floodplain on a ridgetop-terrace; 320 m northeast of Southern Railway line near junction with Rd A-17	300 x 700 (not well defined)	Early Woodland (?; ceramic prehistoric)	--	Possible reoccupations of short duration; no subsurface exploration.
38BR55	Confluence of Steel Creek and Meyers Branch; along terrace edges of both streams from 36.6 m to 4.27 m contours	100 x 600	Middle Archaic to Mississippian	--	Subsurface studies show cultural deposits about 1 m thick; approximate artifact density of 400/m ³ ; likely base camp or habitation site throughout most of prehistoric time since Middle Archaic; eligible for inclusion in the National Register.

Table E-1. Steel Creek archeological sites (continued)

Site number	Approximate location	Approximate size (m)	Prehistoric occupation ^a	Historic occupation	Remarks
38BR56	200 m east of floodplain along Seaboard Coast Line Railroad line; 625 m north of Steel Creek and Meyers Branch confluence	50 x 80	Lithic prehistoric	—	Most of site is distributed beyond recovery by construction of railroad during early 1980s; no subsurface exploration--exposed in railroad cut; lacks temporally diagnostic materials.
38BR102	125 m west of floodplain; along Rd B-5, about 180 m west of Rd B-5/A-14 junction	100 x 350	Late Archaic to Early Woodland	Pre-Civil War (1780-1830) to 1900	Site exposed during construction of transmission line; represents sandhill environmental zone and locus of limited activity.
38BR112	On and adjacent to Steel Creek about 200 m north of Rd A (125)	100 x 100	Lithic prehistoric	1814 to 1950	Historic mill and dam site across floodplain and prehistoric to the east of Steel Creek, which served as a limited-activity locus; absence of temporally diagnostic prehistoric artifacts; eligible for inclusion in the National Register.

Table E-1. Steel Creek archeological sites (continued)

Site number	Approximate location	Approximate size (m)	Prehistoric occupation ^a	Historic occupation	Remarks
38BR187	30+ m west of floodplain	250 x 1050	Early to Late Woodland	Post-1880 to 1940	Considered a single archeological scatter (composed of 38BR184, -185, -186, -187); some historic ruins near site; long occupation (with habitation) during Woodland; no subsurface exploration.
38BR259	100 m west of floodplain; 250 m west of Rd B-4 and 1690 m south of Rd B	50 x 120	Early Woodland	--	Artifacts found to a depth of about 80 cm; served as limited-activity locus and habitation; used for processing nuts and seeds.
38BR263	140 m west of floodplain; 100 m north of termination of Rd A-14.1 and 1780 m south of Rd B	50 x 50	Woodland (?, ceramic prehistoric)	--	No subsurface exploration; lacks temporally diagnostic materials; served as limited-activity locus.
38BR264	Along west side of floodplain; at terminus of Rd A-14.1.	50 x 50	Lithic prehistoric	--	Site disturbed by transmission line construction; lacks temporally diagnostic materials; served as limited-activity locus.

Table E-1. Steel Creek archeological sites (continued)

Site number	Approximate location	Approximate size (m)	Prehistoric occupation ^a	Historic occupation	Remarks
38BR265	100 m west of floodplain; 500 m north of Rd A-16	30 along north-south axis	Late Woodland (?)	--	No subsurface exploration; width of site is unknown; general lack of temporally diagnostic materials.
38BR268	150 m east of floodplain; 300 m from Rd A-14/B-5 junction	50 x 100	Early Woodland	--	Disturbed by earthwork for pre-1950 road maintenance; episodic limited-activity locus.
38BR269	On and beyond east side of floodplain; at termination of Rd A-17 on west and A-19 on east	Prehistoric site >40 x >80	Paleo-Indian- Early Archaic (?; Lithic prehistoric)	1788 (dam) site occupied through 1840	Historic mill dam site and associated prehistoric and historic artifact scatters; terrestrial portion of site is on the 30-m terrace of Savannah River; prehistoric artifact concentrations 160 and 210 m E of floodplain; artifacts to a depth of 45 cm; site of prehistoric habitation; eligible for inclusion in the National Register.
38BR271	300 m north of Savannah River swamp east of the delta; 1 km west of BM 131	40 x 60	Lithic prehistoric	--	No subsurface exploration early stage of lithic tool manufacture, but lacks temporally diagnostic materials.

Table E-1. Steel Creek archeological sites (continued)

Site number	Approximate location	Approximate size (m)	Prehistoric occupation ^a	Historic occupation	Remarks
38BR286	On east and west floodplain; 1786 path includes portions of Rds A-17.1 and A-18 west and east of Steel Creek, respectively	width = 7	--	1786-1940	Historic road and bridge approach; bridge known as Steel Creek Bridge; in 1966, when Steel Creek water level was maximum, water passed through the central area of the bridge pilings and approaches. No evidence of bridge piling found in 1981; eligible for inclusion in the National Register.
38BR288	On east side of floodplain; opposite Rd A-17.1/A-17.2 junction on west side of Steel Creek	5 x 3 at top	--	Before 1818-1840	Historic mill and dam site with several timbers remaining in water; eligible for inclusion in the National Register.
38BR291	125 m west of floodplain; 140 m south of Rd A-14.1 and 380 m north of Rd A-14	30 x 50	--	1770-1840	Historic artifact scatter site with no evidence of foundations or architectural features.

^a(?) = prehistoric lithic and/or ceramic debris--no specific time period.

Table E-2. Archeological resource summary for site recovery determined by Steel Creek survey

Site number	Period(s) of occupation ^a	Type of site	Eligibility for National Register	Adverse effects from increased water flow	Site preservation recommendations
38BR44	1, 2, 8 (1780-1930)	Limited activity	No	None	None
38BR45	4, (?)	Limited activity	No	None	None
38BR56	(?)	Limited activity	No	None	None
38BR102	3, 4, 8 (1780-1900)	Limited activity	No	None	None
38BR263	(?)	Limited activity	No	None	None
38BR264	(?)	Limited activity	No	None	None
38BR265	6	Limited activity	No	None	None
38BR268	4	Limited activity	No	None	None
38BR271	(?)	Limited activity	No	None	None
38BR291	8 (1760-1840)	Historic	No	None	None
38BR438	2, 3, 4	Habitation	No	None	None
38BR112	(?), 8 (1780-1940)	Limited activity, mill dam	Yes	Possible	Preserve vegetation cover and monitor
38BR187	4, 5, 6	Habitation	No	Possible	None
38BR259	4	Habitation	No	Possible	None
38BR269	(?), 8 (1780-1840)	Habitation, mill dam	Yes	Possible	Preserve vegetation cover and monitor
38BR286	8 (1780-1940)	Historic roadway	Yes	Possible	Preserve vegetation cover and monitor
38BR288	8 (1800-1870)	Mill dam	Yes	Possible	Preserve vegetation cover and monitor
38BR55	1, 2, 3, 4, 5, 6, 7	Habitation	Yes	Possible	Monitor erosion, provide erosion protection, data recovery

^a1 = Early Archaic Period (9500-7500 B.C.); 2 = Middle Archaic Period (7500-3000 B.C.); 3 = Late Archaic Period (3000-1000 B.C.); 4 = Early Woodland Period (1000 B.C.-A.D. 1); 5 = Middle Woodland Period (A.D. 1-700); 6 = Late Woodland Period (A.D. 700-1000); 7 = Mississippian Period (A.D. 1000-1700); 8 = Historic Period (A.D. 1700-present); and (?) = Prehistoric lithic and/or ceramic debris--no specific time period.

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of Steel Creek during periods of high water flow experienced with past reactor operations and physical inspection of the site did not reveal any adverse effects during the increased water flow conditions. In July 1982, DOE requested the concurrence of the Keeper of the National Register regarding this site's eligibility for nomination to the National Register. The Keeper of the National Register concurred in this site's eligibility for inclusion in the National Register.

E.1.5 Mitigation plan for the sites eligible for inclusion in the National Register

Those sites eligible for inclusion in the National Register (prehistoric site 38BR55, three mill dams, and a roadway) will be protected by a mitigation plan designed to prevent possible destruction caused by the increased water flow down Steel Creek. A physical inspection of the four historic earthen features to determine the presence and extent of erosion due to increased water flow indicated no erosion. A major reason for the lack of erosion appears to be the stabilizing effect of the trees and vegetation cover. The preservation of these four sites will be ensured by allowing and encouraging the continued growth of trees and vegetation. The prehistoric site will be subjected initially to a monitoring program that involves placing and checking erosion control stakes on the upstream edge of the site along Steel Creek. If the stakes indicate any erosion of the site edge, erosion barriers will be built. If the erosion barrier is not sufficient to protect the site, data recovery will become necessary; the probability of this is low because previous high-water levels did not affect the site. If erosion is not evident after two years of monitoring, the site will be considered sufficiently protected.

E.2 REGIONAL ARCHEOLOGICAL AND HISTORICAL RESOURCES

In 1982, 62 sites in the six-county area near Savannah River Plant were listed in the National Register of Historic Places (Table E-3). Richmond County, Georgia, has the largest number of sites (26), most in and around the City of Augusta; Aiken County, South Carolina, has 15 sites. Fifteen of the 62 sites are within 15 kilometers of Savannah River Plant.

Table E-3. National Register sites in the six-county area near Savannah River Plant^a

Name	Location
AIKEN COUNTY, SOUTH CAROLINA	
Chancellor James Carrol House	Aiken
Coker Springs	Aiken
Legare-Morgan House	Aiken
Phelps House	Aiken
Dawson-Vanderhorst House	Northeast of Aiken
Fort Moore-Savano Town site	Beech Island vicinity
Redcliffe	Northeast of Beech Island
Graniteville Historic District	Graniteville
Silver Bluff	West of Jackson
Charles Hammond House	North Augusta
Rosemary Hall	North Augusta
Joye Cottage	Aiken
Chinaberry (Williams-Converse House)	Aiken
St. Mary Help of Christian Church	Aiken
Willcox's	Aiken
ALLENDALE COUNTY, SOUTH CAROLINA	
Antioch Christian Church	Southwest of Allendale
Erwin House	Southwest of Allendale
Gravel Hill Plantation	Southwest of Allendale
Red Bluff Flint Quarries	Allendale vicinity
Roselawn	Southwest of Allendale
Smyrna Baptist Church	South of Allendale
Lawton Mounds	Johnsons Landing vicinity
Fennell Hill	Peeples vicinity
BAMBERG COUNTY, SOUTH CAROLINA	
General Francis Marion Bamberg House	Bamberg
Woodlands	SE of Bamberg
Rivers Bridge State Park	Ehrhardt vicinity
Voorhees College Historic District	Denmark vicinity
BARNWELL COUNTY, SOUTH CAROLINA	
Banksia Hall	Barnwell
Church of the Holy Apostles	Barnwell
Church of the Holy Apostles Rectory	Barnwell
Old Presbyterian Church	Barnwell
Bethlehem Baptist Church	Barnwell

Table E-3. National Register sites in the six-county area near Savannah River Plant^a (continued)

Name	Location
COLUMBIA COUNTY, GEORGIA	
Kiokie Baptist Church	Appling
Stallings Island	Northwest of Augusta
Woodville	Winfield vicinity
Columbia County Courthouse	Appling
RICHMOND COUNTY, GEORGIA	
Academy of Richmond County	Augusta
Augusta Canal Industrial Historic District	Augusta
Augusta Cotton Exchange	Augusta
Stephen Vincent Benet Home	Augusta
Brake House	Augusta
Landmark Baptist Church of Augusta	Augusta
Fitzsimmons-Hampton House	Augusta
Gertrude Herbert Art Institute	Augusta
Harris-Pearson-Walker House	Augusta
Meadow Garden	Augusta
Old Medical College Building	Augusta
Old Richmond County Courthouse	Augusta
Sacred Heart Catholic Church	Augusta
St. Paul's Episcopal Church	Augusta
Augusta National Golf Club	Augusta
Gould-Weed House	Augusta
Lamar Building	Augusta
Reid-Jones-Carpenter House	Augusta
Woodrow Wilson Boyhood Home	Augusta
College Hill	Augusta vicinity
Broad Street Historic District	Augusta
Pinched Gut Historic District	Augusta
Summerville Historic District	Augusta
Greene Street Historic District	Augusta
Springfield Baptist Church	Augusta
Meadow Garden-George Walton House	Augusta

^aData from USDOl (1979, 1980, 1981, 1982, 1983).

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APPENDIX F

SUBSURFACE HYDROLOGY*

F.1 REGIONAL HYDROGEOLOGY

F.1.1 Regional geology and physiography

The Savannah River Plant (SRP) is located in the Upper Atlantic Coastal Plain, about 40 km southeast of the Fall Line, which separates the Piedmont and Coastal Plain provinces (Figure F-1). The coastal plain is underlain by a wedge of seaward-dipping unconsolidated and semiconsolidated sediments which increase in thickness from zero at the Fall Line to greater than 950 meters near the coast of South Carolina (Rankin, 1977) and continues to the seaward edge of the Continental Shelf. The topographic surface of the coastal plain slopes gently seaward as do the geologic units underlying this surface.

The Savannah River Plant lies on the Aiken Plateau as defined by Cooke (1936). The Aiken Plateau is bounded by the Savannah and Congaree Rivers (Figure F-1), and slopes from an elevation of 200 meters (above mean sea level) at the Fall Line to an elevation of about 76 meters. The surface of the Aiken Plateau is highly dissected and is characterized by broad interfluvial areas with narrow steep-sided valleys. Relief is locally as much as 90 meters (Siple, 1967). The Plateau is generally well drained although small poorly drained depressions occur. Drainage is poor in the low-lying river swamp areas.

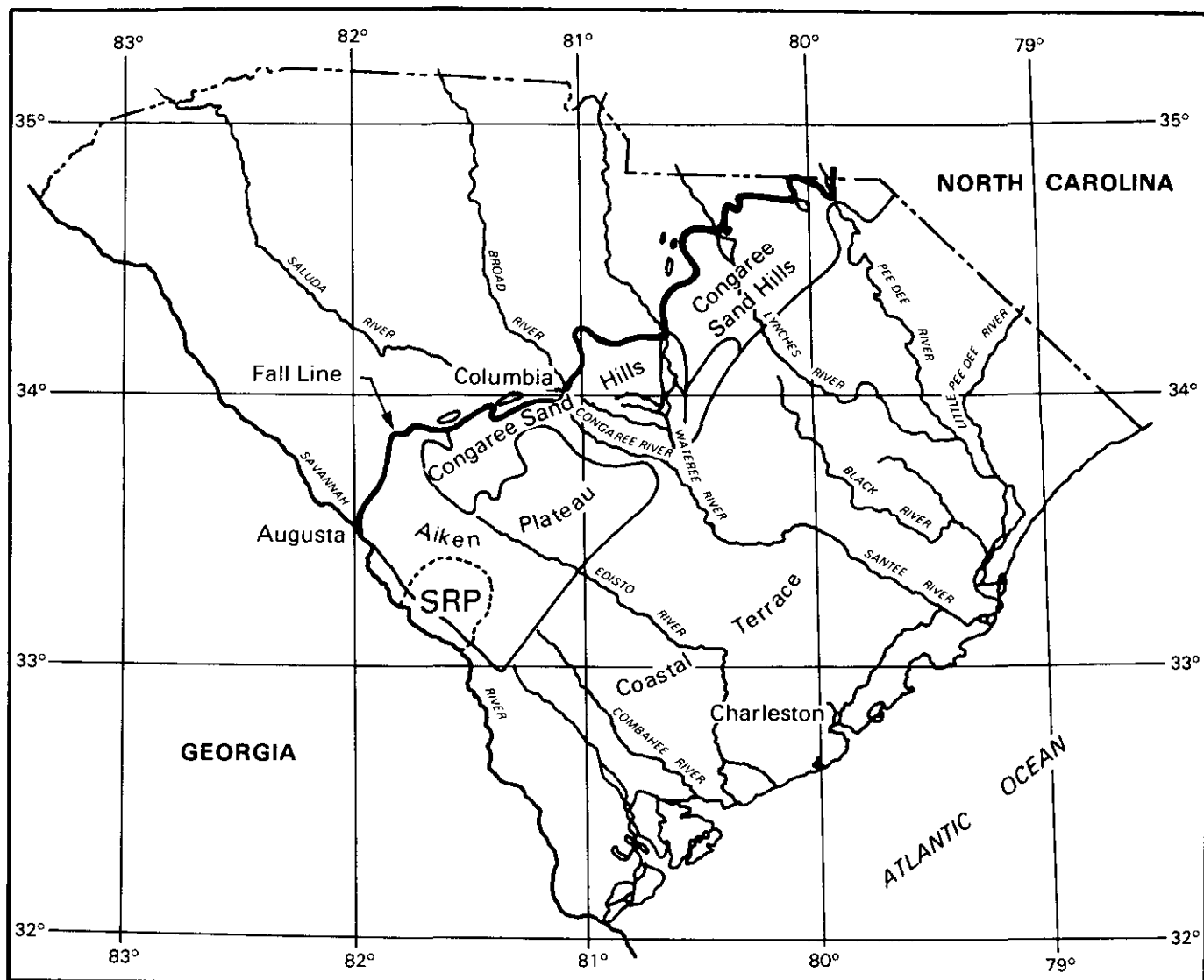
The Savannah and Congaree Rivers are the largest in the region. The Savannah River forms the boundary between South Carolina and Georgia. The river has a flood plain 6 to 8 kilometers wide downstream from Augusta, Georgia, and a stream gradient of about 1.9×10^{-4} adjacent to the Savannah River Plant.

Between the Savannah and the Congaree Rivers are the North and South Forks of the Edisto River and the Salkehatchie River. Both of these rivers originate on the coastal plain and flow southeastward into the Atlantic Ocean. These rivers do not incise their valleys as deeply into the sediments as do the Savannah and Congaree Rivers. On the Aiken Plateau there are several southwest flowing tributaries to the Savannah River. From the Fall Line these are Horse Creek, Hollow Creek, Upper Three Runs Creek, Four Mile Creek, Pen Branch, Steel Creek, and Lower Three Runs Creek (Figure F-2).

The sediments of the Atlantic Coastal Plain in South Carolina are stratified gravel, sand, clay, and limestone which dip gently seaward; there are local variations in dip and thickness due to locally variable depositional regimes. The base of the coastal plain sediments lies on the weathered surface of the crystalline metamorphic rock that dips at a gradient of about 6.8×10^{-3} from the Fall Line. Imbedded in the crystalline metamorphic rock is at least one sedimentary basin of Triassic age. The basin is comprised of sedimentary rocks that are buff to maroon in color and contain poorly sorted sands and clays.

|TC

*This appendix is developed primarily from Du Pont (1983).

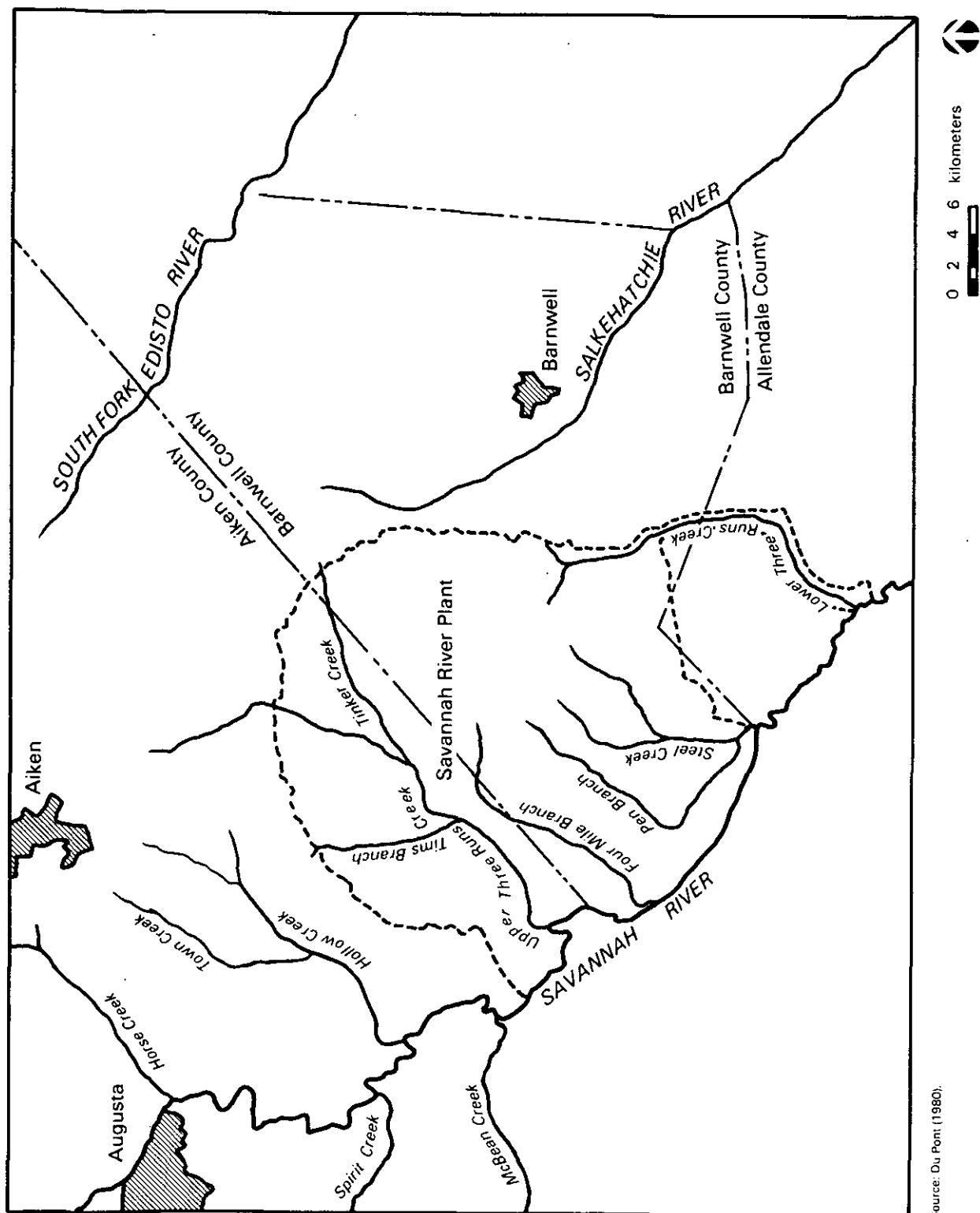


Source: Du Pont (1980).

0 30 60 kilometers



Figure F-1. Physiography of the Savannah River region.



Source: Du Pont (1980).

Figure F-2. Surface hydrologic features in the vicinity of the Savannah River Plant.

The erosional surface on the crystalline metamorphic rock is continuous across the Triassic basin and has a very low relief.

The structural setting of the Atlantic Coastal Plain is a monoclinal dip of gradient 1.7×10^{-3} to 6.8×10^{-3} to the southeast with some local variations. The Triassic basins beneath the coastal plain were created by tensional rifting and erosion from fault block mountains and deposition into fault block valleys, much as is occurring today in the basin and range province of Utah and Nevada.

F.1.2 Regional hydrology

Water moves through the ground from areas of high potential energy (the combined elevation and pressure heads) to areas of lower energy. In general, on the Atlantic Coastal Plain, this involves ground water moving seaward from the higher areas of the Aiken Plateau toward the Continental Shelf. Because most sedimentary units become finer grained and less transmissive toward the coast, this movement becomes exceedingly slow. Of major significance is the modification from this general southeastward movement caused by the incision of the Savannah and Congaree Rivers. Ground water in the regions of these rivers flows toward the hydraulic-energy low caused by discharge to the surface in these river valleys. Savannah River Plant is totally on the Savannah River side of the ground-water divide that occurs between these two rivers. Thus, the regional ground water of interest will have directions of flow determined by the relationship of the ground water to the Savannah River Valley.

The depth of dissection by the southwestward-flowing tributaries has a significant influence on the direction of flow in most hydrostratigraphic units. In general, the direction of flow in the shallow ground water is most affected by small tributaries, deeper ground water by major tributaries, and deepest ground water only by the Savannah River itself. It is not unusual to have the deepest ground water moving at right angles, or even in the opposite direction to the shallow ground water at a particular location because of differences in stream incision.

The depth to the water table (the beginning of the saturated zone, below which all pores are filled with water and above which pores are partially filled with air) ranges from zero to about 38 meters below the surface. The depth to the water table is dependent on the horizontal and vertical hydraulic conductivity, topographic drainage and local surface water conditions. In some places where interbedded clays are common, the vertical movement of water is impeded and shallow or locally perched water tables exist. In other places where these clays are not present, the water table may be very deep. The water table generally slopes in the same direction but more gently than the land surface. Thus, deeper water tables commonly exist near the cuesta face of the asymmetrical tributary creek valleys, that is, the southeast side of the valleys; whereas shallower water tables exist on the northwest side.

As used in this appendix, the SRP vicinity extends only to those distances that could have a cause-effect relationship to ground water at Savannah River Plant. This distance ranges from about 64 kilometers from the center of the

plant in a northerly direction to about 32 kilometers in a southeasterly direction. Even though the geologic names used for some of the water-bearing units at SRP extend to great distances, the hydrologic relationships do not. Thus, the hydrologic region is much more restricted than the geologic region.

The coastal plain sediments constitute a multilayer hydrologic system in which there are both retarding and transmitting beds, so that parts of it may be somewhat hydrologically isolated from other parts. Hydraulic properties vary for each of the hydrostratigraphic units, depending on their lithology. Ground-water flow paths and flow velocities for each of these units are governed by the hydraulic properties, by the geometry of the particular unit, and by the distribution of recharge and discharge areas.

Because of the sandy nature of the sediments and the comparatively short residence time of ground water (centuries), the water in the coastal plain sediments is low in dissolved solids. Most of the waters have a low pH (about 5.5) and are generally corrosive to metal surfaces.

F.1.3 Formation terminology

In order to discuss the geology and hydrology of the region and of the Savannah River Plant specifically, it is convenient to designate parts of the geologic column with names. Historically, the criteria for designating geologic units with names is well established, but in practical application, this topic is sometimes confusing. Ideally, each geologic unit should have a set of physical and visually observable characteristics that distinguish it from other units in the area. When a geologic unit has such a set of characteristics and is thick enough and extensive enough to be shown on the usual scale of geologic mapping, it is called a "formation" and receives a formal name. These names are designated and accepted through publication in the open refereed literature according to certain rules.

The terminology for the hydrostratigraphic units used in this report (Table F-1) is modified from that used by Siple (1967). Table F-1 describes the lithology and water-bearing characteristics of these units. These terms, as modified, have been found very useful in numerous studies of ground water at the SRP. Figure F-3 is a cross section through SRP from the Fall Line showing the relationship of the units discussed in Table F-1. Figure F-4 shows a tentative correlation of these units to stratigraphic terminology being described in current publications. However, the thrust of much of this current literature is on biostratigraphy and regional correlation of mappable units and not on hydrostratigraphy. Thus, for purposes of this appendix, the older terminology is retained.

F.1.4 Water-level measurements

Water levels used to construct piezometric maps presented in this appendix were measured in monitoring wells (not in pumping wells) during normal plant operations, including the withdrawal of process and domestic water from ground-water sources.

EL-24

Table F-1. Hydrostratigraphic units in the vicinity of SRPa,b,c

Formation	Recharge	Discharge	Confining layers	Other characteristics
BARNWELL (& HAWTHORN)				
Surficial unit	Winter rainfall is	Onsite streams.	Tan clay at base;	Fine to coarse sand and sandy clay
Miocene-Eocene	31.2 cm/year.	Leakage through	absent in M-Area	with numerous clastic dykes
Epoch, Tertiary	Total recharge is	tan clay to		(ironstone margin with clay
Period	about 38 cm/year.	McBean.		center).
30 m thick in				"Tan clay" - 4-m thick unit at
Separations Area				base of formation composed of 2
				clay zones separated by a sandy
				zone. Tan clay is absent in
				A/M-Areas.
				Water-table aquifer in the central
				portion of SRP, but not in
				A/M-Areas.
				Water yield limited but sufficient
				for domestic use.
				Water table maps--Figs. 3-10,
				F-21, and F-24.
				L-Area cross-section--Fig. F-22.
				$K_L = 0.6$ m/day (Fig. F-19; also
				see Fig. F-14 and Table F-7).
				$j = 0.2 - 0.25$.
				$I = 0.0188$ (L-Area seepage basin
				to Steel Creek with 2-m head in
				basin).
				$K_V(\text{tan clay}) = 1.6 \times 10^{-3}$
				m/day.
				$V_L = 365IK_L/j = 20.6$ m/year.
				$V_L = (14.5)$ (% gradient)
				m/year.

AW-1,
FE-2

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics
BARNWELL (& HAWTHORN) (continued)				
				$V_Y = 2.1$ m/year (unsaturated zone). Seepage rate from F-, H-, and M-Area seepage basins about 5.5 m/year because of constant discharges and low pH of waste streams.
MCBEAN				
Eocene Epoch, (Claiborne Group), Tertiary Period 24 m thick in Separations Area	From Barnwell (through tan clay in Central SRP). Offsite areas.	Upper Three Runs Creek and Four Mile Creek. Almost no leakage through the green clay to Congaree in central SRP; some leakage in A/M-Areas.	Tan clay at top; absent in A/M-Areas Green clay at base; discon- tinuous in A/M-Areas	Upper unit of clayey sands and sand; lower unit of calcareous clayey sand with void spaces that could result in rod drops or lost circulation during drilling operations. Calcareous zone with void spaces is not present in A/M-Areas. Corps of Engineers performed soil grouting of calcareous zone beneath major buildings. Green clay at base formation is 2 m thick in Separations Area, and supports head differences up to 24 m. Green clay is discontinuous in A/M-Areas, and thickens to 7 m in L-Area and to 18 m in the southeastern SRP. Water yields to wells moderate to large. Forms water-table aquifer in M-Area; elevations range from about 65 to 75 m.

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics
MCBEAN (continued)				
				Water levels shown on Figs. 3-8, F-5, F-11, F-15, F-16, F-20, and F-33.
				Main body of contaminant plume in the A/M-Areas is moving at 7.6 m/year; this suggests $K_L = 1.0$ m/day. Outer fringe of plume is moving at about 76 m/year.
				Hydraulic conductivity of upper McBean is about twice that of lower McBean (0.13 versus 0.07 m/day; Table F-7).
				$K_L = 0.9$ m/day (Fig. F-19; also see Fig. F-14 and Table F-7).
				$j = 0.20 - 0.25$.
				$I = 0.017$.
				$V_L = 365IK_L/j = 27.9$ m/year.
CONGAREE				
Eocene Epoch, (Claiborne Group), Tertiary Period	Principally in offsite areas; some leakage from McBean in A/M-Areas.	Savannah River and wetlands along upper Three Runs Creeks.	Green clay at top; discontinuous in A/M-Areas	Sand with some interbedded clay layers (absent in A/M-Areas). Becomes clayey sand in A/M-Areas, and is similar in character to McBean.
37 m thick in Separations Area			Pisolitic clay at base	Pervasive pisolitic clay at base correlates with similar clays in Gulf Coast.

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics
CONGAREE (continued)				
		Almost no leakage downward through basal clay and upper Ellenton clay to Ellenton sands, or upward through green clay.	Top of Ellenton	Water yields to wells moderate to high: Central SRP: 2.5 m³/min with 15-meter drawdown; A/M-Areas: 0.11 m³/min with 9-meter drawdown. Water levels shown on Figs. 3-8, F-5, F-10, F-11, F-16, F-17, F-18, F-28, F-29, and F-33. $K_V = 1.8 \times 10^{-4}$ m/day (of basal clay) Hydraulic conductivity: F/H-Areas: $K_L = 1.5$ m/day (Table F-7; Fig. F-14). C/P-Areas: $K_L = 40$ m/day. A/M-Areas: $K_L = 0.7$ to 1.0 m/day. Effective porosity: F/H-Areas: $j = 0.20$. A/M-Areas: $j = 0.14$. $I = 0.0015$ to 0.005. $V_L = 365IK_L/j =$ F/H-Areas: 13.7 m/year. A/M-Areas: 3.2 m/year.

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics
ELLENTON				
Upper Cretaceous (Period) or Paleocene Epoch of Tertiary Period 18 m thick in Separations Area No surface exposure	From underlying Tuscaloosa and offsite areas.	Upper clay layer of Tuscaloosa may be discontinuous or contain sandy zones which permit communication.	Lower pisolitic clay of Congaree Upper clay layer of Ellenton Upper clay layer of Tuscaloosa; usually not effective confining layer	Upper 3-5 m thick lignitic clay, silty and sandy clay layer, becoming thicker toward northwest (10 m in A/M-Areas). Lower layer of medium-to-coarse clayey quartz sand. Permeable portion of Ellenton and upper Tuscaloosa considered to be single aquifer. Water levels shown on Figs. 3-8, F-5, F-10, F-12, F-27, and F-33. $K_v = 9.8 \times 10^{-5}$ m/day (of upper clay unit).
TUSCALOOSA				
Upper Cretaceous (Period) 180 m thick in Separations Area	Principally from offsite areas - outcrop area 15-50 km wide in South Carolina near the Fall Line and in major stream valley (see Figs. F-7 and F-31).	Upper Tuscaloosa to lower unit of Ellenton. Ground water beneath SRP flows to sink along Savannah River.	Upper clay layer of Ellenton Upper clay layer of Tuscaloosa; usually not effective confining layer Basal clay layer	Two aquifer units within Tuscaloosa separated by clay layer: Upper layer of clay, sandy clay, and clayey sand 18 m thick allows communication with Ellenton aquifer. Upper aquifer of well-sorted medium to coarse sand 46 m thick. Middle layer 12 m thick with one or more clay units. Lower aquifer of well-sorted medium to coarse sand 92 m thick.

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics										
TUSCALOOSA (continued)														
				Basal clay layer 12 m thick overlying saprolitic basement.										
				Water yields to wells are large with 3.5-4.0 m ³ /min wells having drawdowns of 6-12 meters at center of cone of depression and during pumping tests. Drawdowns are typically 0.3 m 490-700 m from pumping well.										
				Water levels shown on Figs. 3-8, F-5, F-6, F-7, F-8, F-9, F-10, F-11, F-12, F-16, F-22, F-27, F-28, F-29, and F-33.										
				In central SRP, heads in Tuscaloosa are higher than Congaree heads; opposite is true in A/M-Areas. Differences beneath seepage basins are currently about:										
				<table><tr><th>Area</th><th>Upward differential (m)</th></tr><tr><td>L</td><td>3.7</td></tr><tr><td>F</td><td>7.6</td></tr><tr><td>H</td><td>3.0</td></tr><tr><td>M</td><td>-5.5</td></tr></table>	Area	Upward differential (m)	L	3.7	F	7.6	H	3.0	M	-5.5
Area	Upward differential (m)													
L	3.7													
F	7.6													
H	3.0													
M	-5.5													
				Transmissivity (11 values):										
				Mean is 1.5 x 10 ⁶ l/day/m ² .										
				Mean is 1.4 x 10 ⁶ l/day/m ² .										
				Storage coefficient (mean of 7 values) is 4.5 x 10 ⁻⁴ .										

AW-1,
FE-2

Table F-1. Hydrostratigraphic units in the vicinity of SRP^{a,b,c} (continued)

Formation	Recharge	Discharge	Confining layers	Other characteristics
TUSCALOOSA (continued)				
				$K_L = 40.8 \text{ m/day.}$ $j = 0.2 - 0.30.$ $I = 0.0007.$ $V_L = 365IK_L/j = 52.2 \text{ m/year.}$

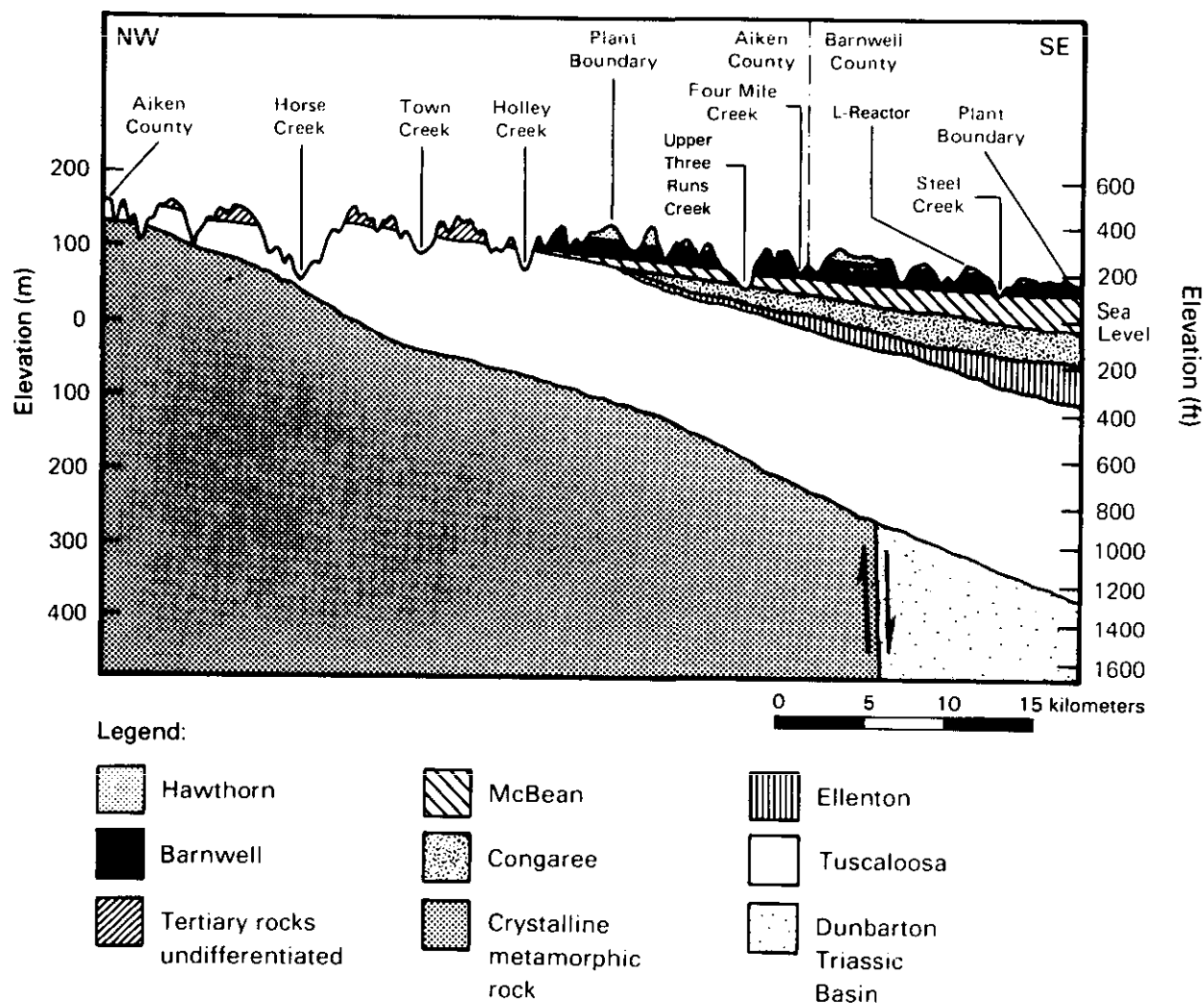
^aAdditional descriptive information is presented in Table 3-8.

^bAbbreviations:

K_L = Lateral hydraulic conductivity
 K_V = Vertical hydraulic conductivity
 I = Hydraulic gradient (decimal)
 j = Effective porosity (decimal)
 V_L = Lateral ground-water velocity
 V_V = Vertical ground-water velocity

^cSources: Du Pont (1983c); Root (1983)

AW-1,
FE-2

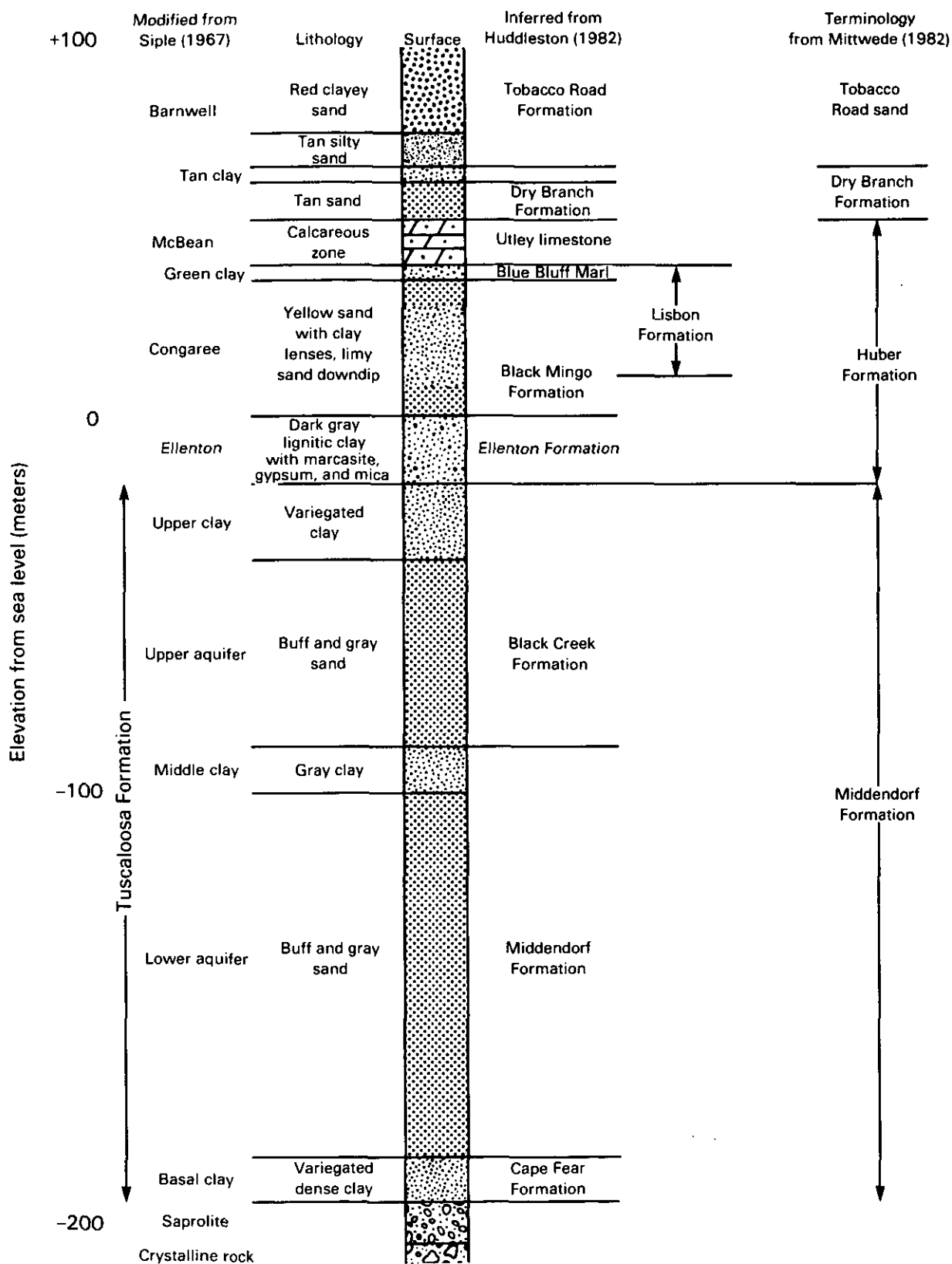


Note: Figure F-6 shows the location of this geologic profile.

Source: Siple (1967).

TC

Figure F-3. Generalized northwest to southeast geologic profile across the Savannah River Plant.



Source: Du Pont (1983).

Figure F-4. Tentative correlation of stratigraphic terminology of the southwestern South Carolina Coastal Plain.

F.2 DESCRIPTION OF THE HYDROSTRATIGRAPHIC UNITS

Three distinct geologic and hydrologic systems exist in the SRP vicinity (Figure F-3):

- The coastal plain sediments where water occurs in porous, unconsolidated to semiconsolidated sands and clays
- The buried crystalline metamorphic basement rock consisting of chlorite-hornblende schist, hornblende gneiss, and lesser amounts of quartzites, where water occurs in small fractures
- A buried Triassic basin consisting mostly of red consolidated mudstone with some poorly sorted sandstones, where water occurs in the intergranular space but is very restricted in movement by the extremely low permeability

Figure F-5 shows the depth and thickness of the hydrostratigraphic units in the coastal plain sediments and the water levels associated with each unit near the center of SRP (H-Area).

F.2.1 Crystalline metamorphic rock

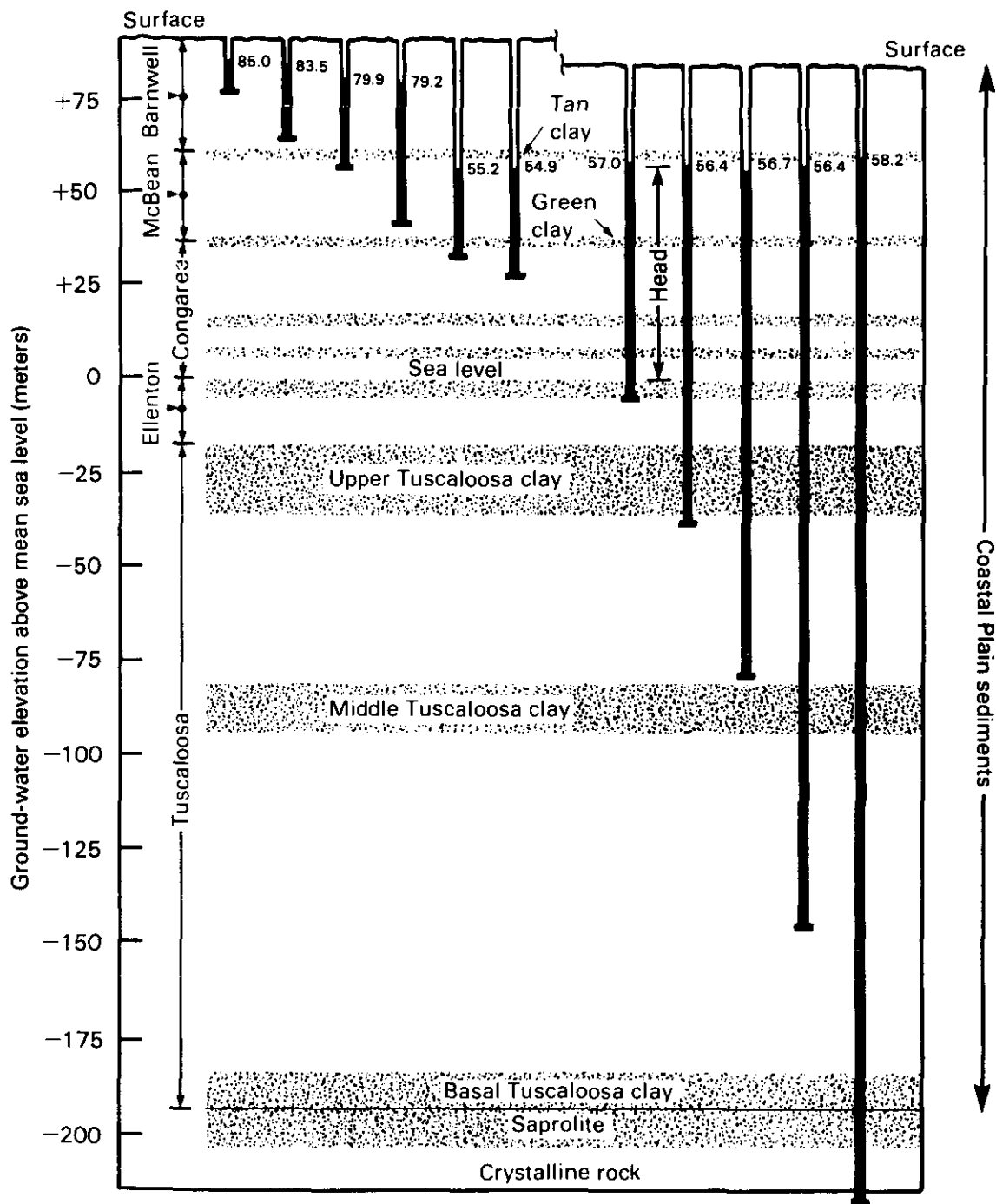
Near the center of SRP the crystalline and metamorphic rock is buried beneath about 280 meters of unconsolidated-to-semiconsolidated coastal plain sediments (Marine, 1967). The surface of the rock dips to the southeast at a gradient of about 6.8×10^{-3} (Siple, 1967), and the rock crops out at the Fall Line about 40 kilometers northwest of SRP.

Water injection and removal tests on packed-off sections of rock indicate that there are two types of fractures in the crystalline rock (Marine, 1966). The first type consists of minute fractures that pervade the entire rock mass but transmit water extremely slowly. Rock that contains only this type of fracture is called "virtually impermeable rock." The other type of fracture is restricted to definite zones that are vertically restricted but laterally correlatable and have larger openings that transmit water faster. Rock that includes this type of fracture is called "hydraulically transmissive rock."

Representative values of the hydraulic conductivity are 1.2×10^{-2} liters per day per square meter for virtually impermeable rock and 33 liters per day per square meter for hydraulically transmissive rock (Marine, 1975). Analysis of a two-well tracer test with tritium indicated a fracture porosity of 0.08 percent in a hydraulically transmissive fracture zone (Webster et al., 1970). Laboratory analyses of cores indicated an average intergranular porosity of 0.13 percent.

Immediately overlying the crystalline rock is a layer of clay (saprolite), which is the residual product of weathering of the crystalline rock. The combined saprolite and basal-Tuscaloosa clay (Figure F-5) at the top of the metamorphic rock form an effective seal that separates water in the coastal plain sediments from water in the crystalline metamorphic rock.

TC



Legend:

85 Water elevation (head)
in well (meters)

Note: Figure F-6 shows well locations.

Sources: ERDA (1977), Du Pont (1983).

Figure F-5. Geology and hydrostatic head in ground water near the center of the Savannah River Plant (H-Area) in 1972.

Except for testing programs, there is no pumpage from the metamorphic rock until the Fall Line is approached. From there westward in the Piedmont Province, the metamorphic rock provides water for domestic use. Because of the prolific aquifer in the overlying coastal plain sediments and the saprolite/clay seal, it is unlikely that the hydrologic regimen of the metamorphic rock will be impacted by Savannah River Plant in this area.

Table F-2 shows a typical chemical analysis of water from the crystalline metamorphic rock. The water has a total dissolved solids content of about 6,000 milligrams per liter, which is largely calcium (500 milligrams per liter), sodium (1,300 milligrams per liter), sulfate (2,500 milligrams per liter), and chloride (1,100 milligrams per liter).

F.2.2 Triassic sedimentary rock

A graben-like basin of mudstone (the Dunbarton Basin), formed by downfaulting of the crystalline metamorphic rock during the Triassic Period, is buried beneath about 370 meters of coastal plain sediments (Figure F-3). The northwest boundary of the basin has been well defined by seismic traverses and by a well that penetrated 490 meters of Triassic rock and then passed into the crystalline metamorphic rock below. The southeast margin is not as well defined because there is no well similarly placed to the one that defines the northwest margin (Marine, 1976a).

The upper surface of the Triassic rock is beveled by the same erosional cycle that created a peneplain on the crystalline rock surface. This surface is now tilted at a gradient of about 6.8×10^{-3} (Siple, 1967), but after correcting for this dip, the surface is extremely flat and featureless. | TC

The depth to the bottom of the Dunbarton Basin is not known from well penetration except along the northwest border. A well near the center of the basin was drilled to a depth of 1,300 meters and did not penetrate crystalline rock.

The Triassic sediments consist of poorly sorted, consolidated gravel, sand, silt, and clay. The coarser material is found near the northwest margin where fanglomerates are abundant. Nearer the center, sand, silt, and clay predominate; however, the sorting is always extremely poor (Marine and Siple, 1974), which causes an extremely low primary permeability in the Triassic rocks. Ground water occurs in the primary porosity of the Triassic clastic rock. However, the hydraulic conductivity is extremely low, and water movement is almost nonexistent.

The hydraulic conductivity of the Triassic sedimentary rock as determined from field tests ranged from 4×10^{-3} to 4×10^{-6} liters per day per square meter (Marine, 1974). The average total porosity was 8.0 percent for sandstones and 3.3 percent for mudstones. The average effective porosity was 7.0 percent for sandstones and 0.53 percent for mudstones.

Table F-2. Chemical analyses of water from metamorphic and Triassic rock at Savannah River Plant

Well	Mineral content, mg/ℓ									Total dissolved solids
	SiO ₂	Fe	Ca	Mg	Na	K	HCO ₃	SO ₄	Cl	
DRB8 Crystalline Rock	7.6	0.03	467	15	1,200	16	18	2,590	900	5,660
DRB9 Triassic	1.0	0.00	518	83	1,120	30	72	420	2,620	5,950
Crystalline Rock	6.1	0.09	461	38	1,440	11	29	2,460	1,260	5,990
P12R	--	0.05	22	7.6	262	9.3	157	<1	330	800
DRB11 Triassic	--	<1	3,845	8.5	2,710	22.1	1	1	11,600	18,500
DRB10	3.5	0.04	1,990	53	2,100	44	85	110	6,720	11,900
54P Coastal Plain	12	0.18	5.0	0.9	1.2	1.0	10.5	14.1	1.4	38

Adapted from Du Pont (1983).

Table F-2 lists some chemical analyses of water samples from the Dunbarton Basin of Triassic age. Samples from the deeper wells (DRB 10 and DRB 11) near the center of the basin had total dissolved solids contents (almost entirely sodium chloride) of 12,000 and 18,000 milligrams per liter.

No water is pumped from the Dunbarton Triassic Basin, nor is there likely to be in the future because of the poor water quality and the low permeability of the rocks.

F.2.3 Tuscaloosa Formation

F.2.3.1 Hydrostratigraphy

The Tuscaloosa Formation consists primarily of fluvial and estuarine deposits of cross-bedded sand and gravel with lenses of silt and clay. It rests directly on saprolite, a residual clay weathered from the crystalline metamorphic rock. The Tuscaloosa is overlain conformably by the Ellenton Formation, but near the Fall Line, where the Ellenton is absent, it is overlain unconformably by sediments of Tertiary and Quaternary age (Siple, 1967). The Tuscaloosa crops out in a belt that extends from Western Tennessee to North Carolina. In South Carolina, this belt is from 15 to 50 kilometers wide. The thickness of the Tuscaloosa ranges from zero at the Fall Line to about 230 meters beneath the L-Reactor site at Savannah River Plant (Figure F-3). The thickness remains fairly constant in the SRP area.

In this region, the Tuscaloosa consists of light gray to white, tan, and buff colored cross-bedded quartzitic to arkosic coarse sand and gravel, with lenses of white, pink, red, brown, and purple silt and clay (Siple, 1967). Ferruginous sandstone concretions, siderite nodules, and lenses of kaolin 0.5 to 12 meters thick are present in the Tuscaloosa. The chief minerals in the sediments are quartz, feldspar, and mica, which were derived from weathering of the igneous and metamorphic rocks of the Piedmont province to the northwest.

In areas of the South Carolina Coastal Plain within about 40 kilometers of the Fall Line, sand beds in the Tuscaloosa Formation form one of the major supplies of ground water. Industrial wells in this aquifer commonly yield more than 3,800 liters per minute of good quality water.

The Tuscaloosa Formation is the thickest (170-250 meters) of the coastal plain formations in this area (Figures F-3 and F-5). Near the center of the SRP area, the units of the Tuscaloosa Formation from top to bottom (Figure F-5) are (1) a unit of clay, sandy clay, or clayey sand about 20 meters thick; (2) an aquifer unit of well-sorted medium to coarse sand about 45 meters thick; (3) a unit, about 12 meters thick, in which one or more clay lenses occur; (4) an aquifer unit of well-sorted medium-to-coarse sand about 90 meters thick; and (5) a basal unit of sandy clay about 12 meters thick. The two aquifer units (2 and 4) combined are about 135 meters thick and are used singly and together to supply water-production wells at SRP. For many purposes, they are treated as one aquifer; however, they are hydraulically separated at Savannah River Plant, except near wells that take water from both units.

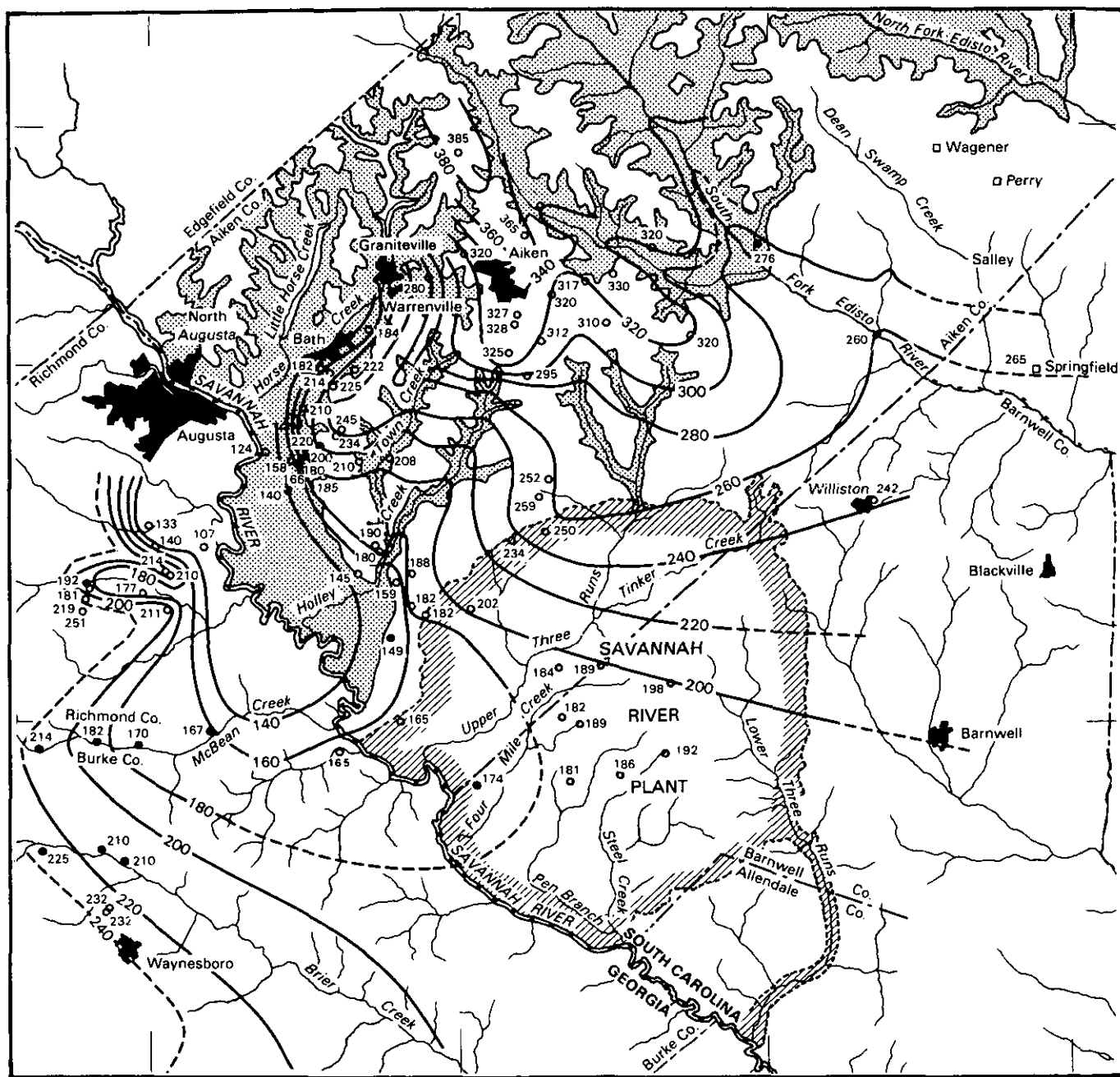
F.2.3.2 Hydrologic characteristics

Field tests of the transmissivity of the Tuscaloosa Formation were made when the original wells were drilled during the construction of Savannah River Plant (Siple, 1967). A representative value of transmissivity is listed in Table F-3 for each area at Savannah River Plant shown on Figure F-6 (Marine and Routt, 1975). The average of these 11 transmissivity values is 1.5×10^6 liters per day per square meter; the median is 1.4×10^6 liters per day per square meter. Storage coefficients were determined for seven regions of the Tuscaloosa Formation (Siple, 1967); the average value is 4.5×10^{-4} . Effective porosities were reasonably assumed to be 20 percent to 30 percent (Siple, 1967).

The location of Savannah River Plant and the outcrop area of the Tuscaloosa Formation are shown together with a piezometric map of the formation in Figure F-7. Where the outcrop area is high in elevation, such as on the Aiken Plateau in the northeast sector (Figure F-7), water recharged to the Tuscaloosa Formation exceeds the water discharged to local streams, and this excess water moves southeastward through the aquifer. Where the outcrop area is low in elevation, such as along the Savannah River Valley in the northwest sector (Figure F-7), water discharges from the formation to the river. Thus, the pattern of flow is arcuate.

Recently (1982) two independent piezometric maps of the Tuscaloosa aquifer have been published. The first of these (Figure F-8) was prepared by Faye and Prowell (1982) based on data from 1945 to 1981. The general piezometric pattern presented on this map is the same as that presented by Siple (1967), and the map shows an arcuate flow pattern toward a sink along the Savannah River. Another piezometric map of the Tuscaloosa Formation was prepared in a study for Georgia Power Company (1982) using only data from May to June 1982. This map (see Figure F-32) also shows a ground-water sink along the Savannah River. All of these maps indicate that ground water in the Tuscaloosa Formation does not cross from South Carolina into Georgia or from Georgia into South Carolina.

The term "Tuscaloosa Formation" has been applied to geologic deposits from North Carolina to Louisiana. This formation is a prolific aquifer in parts of North Carolina, South Carolina, and Georgia. However, the water in the formation that passes beneath Savannah River Plant recharges and discharges from the formation only in Aiken, Barnwell, and Allendale Counties of South Carolina. In general, these three piezometric maps do not distinguish between wells in upper and deeper aquifers of the Tuscaloosa Formation; yet it is known at Savannah River Plant that wells screened near the base of the lower Tuscaloosa that are away from centers of pumpage have a higher water level than those in the upper part of the Tuscaloosa. Figure F-9 is a piezometric map of the Tuscaloosa aquifer on Savannah River Plant. Water-level data from wells screened only at the bottom of the aquifer were not used. Although the data for this map are sparse, flow in the Tuscaloosa toward the Savannah River is confirmed.



Legend:

- 192
Nonflowing well
- 210
Flowing well

 Outcrop area of Tuscaloosa Formation

— 200 —
Piezometric contour—Dashed where approximate

Contours and water elevations in
feet above mean sea level;
1.0 foot = 0.3048 meter.

TC

Figure F-7. Piezometric surface and outcrop area of the Tuscaloosa Formation reproduced from Siple (1967).

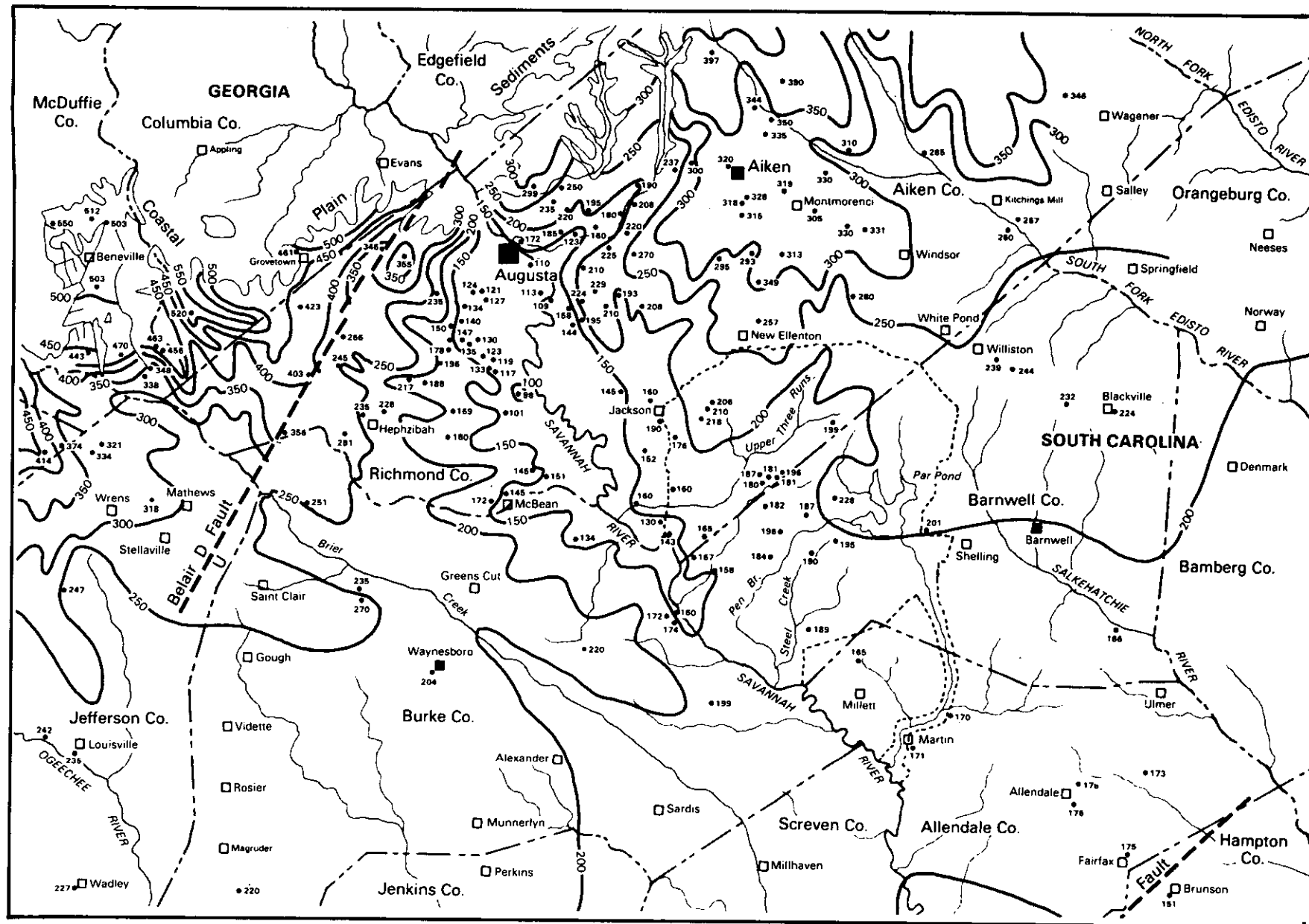
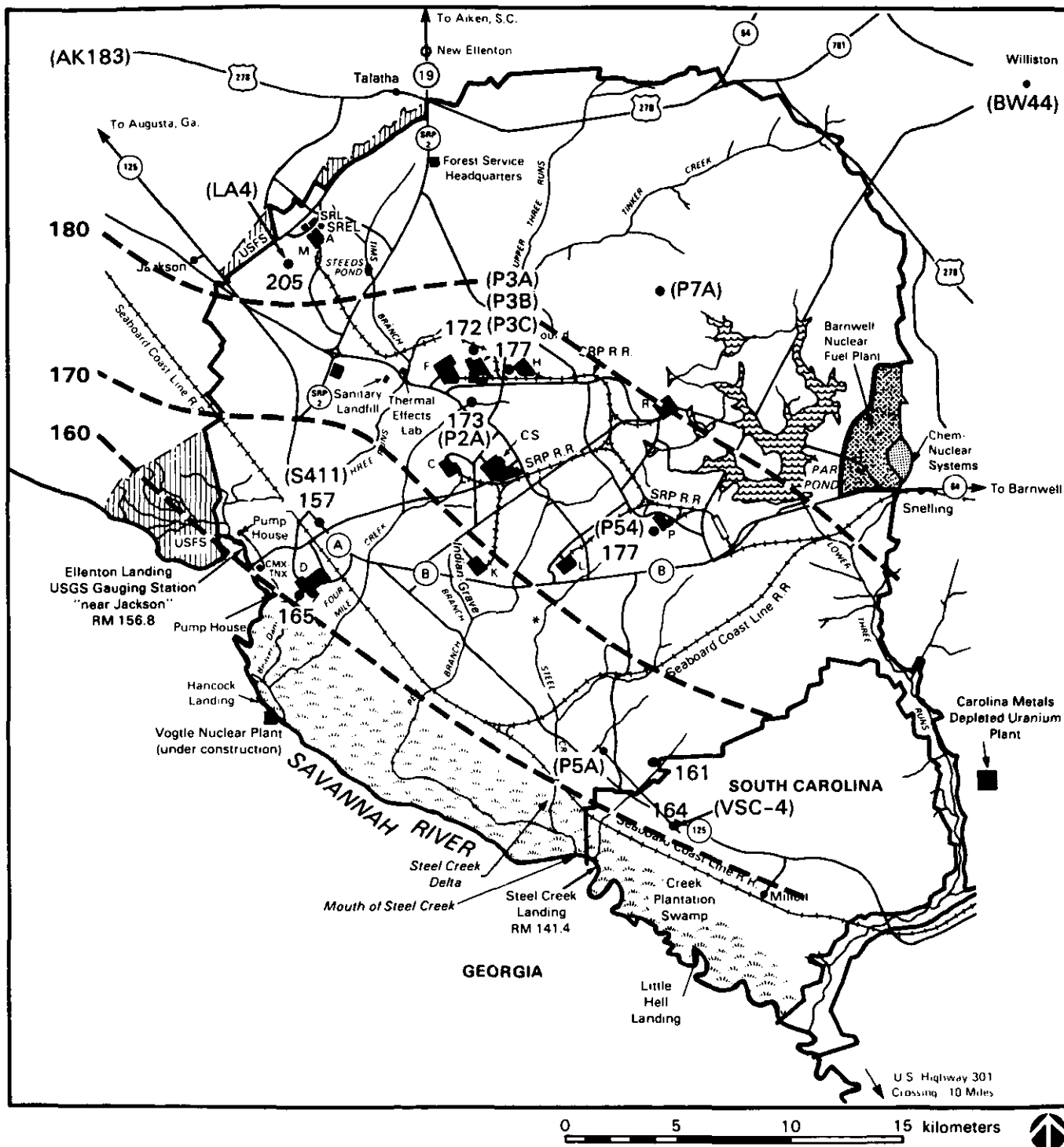


Figure F-8. Piezometric surface of Tuscaloosa Formation (based on Faye and Prowell, 1982).

TC



Note: Contours and water elevations in feet above mean sea level.

1.0 foot = 0.3048 meters.

P5A VSC-4

● Location of profile shown on Figure F-10.

*Abandoned well S329, which could be flooded by a cooling lake on Steel Creek.

Figure F-9. Piezometric map of Tuscaloosa Formation at Savannah River Plant (May 11, 1982) and locations of Tuscaloosa wells (parentheses) for which hydrographs are given in Figures F-12 and F-27.

The relationship of water levels in the Tuscaloosa Formation to those in overlying formations at H-Area in 1972 is shown in Figure F-5. The head in the upper Tuscaloosa is about 1.2 to 1.8 meters above those in the Congaree; however, these particular Tuscaloosa observation wells are within the influence of the cone of depression caused by the continuous pumpage from nearby wells in H-Area. A single water-level measurement in the Tuscaloosa in 1952, before pumping began, indicates a head difference in H-Area 2 meters greater than that measured in 1972.

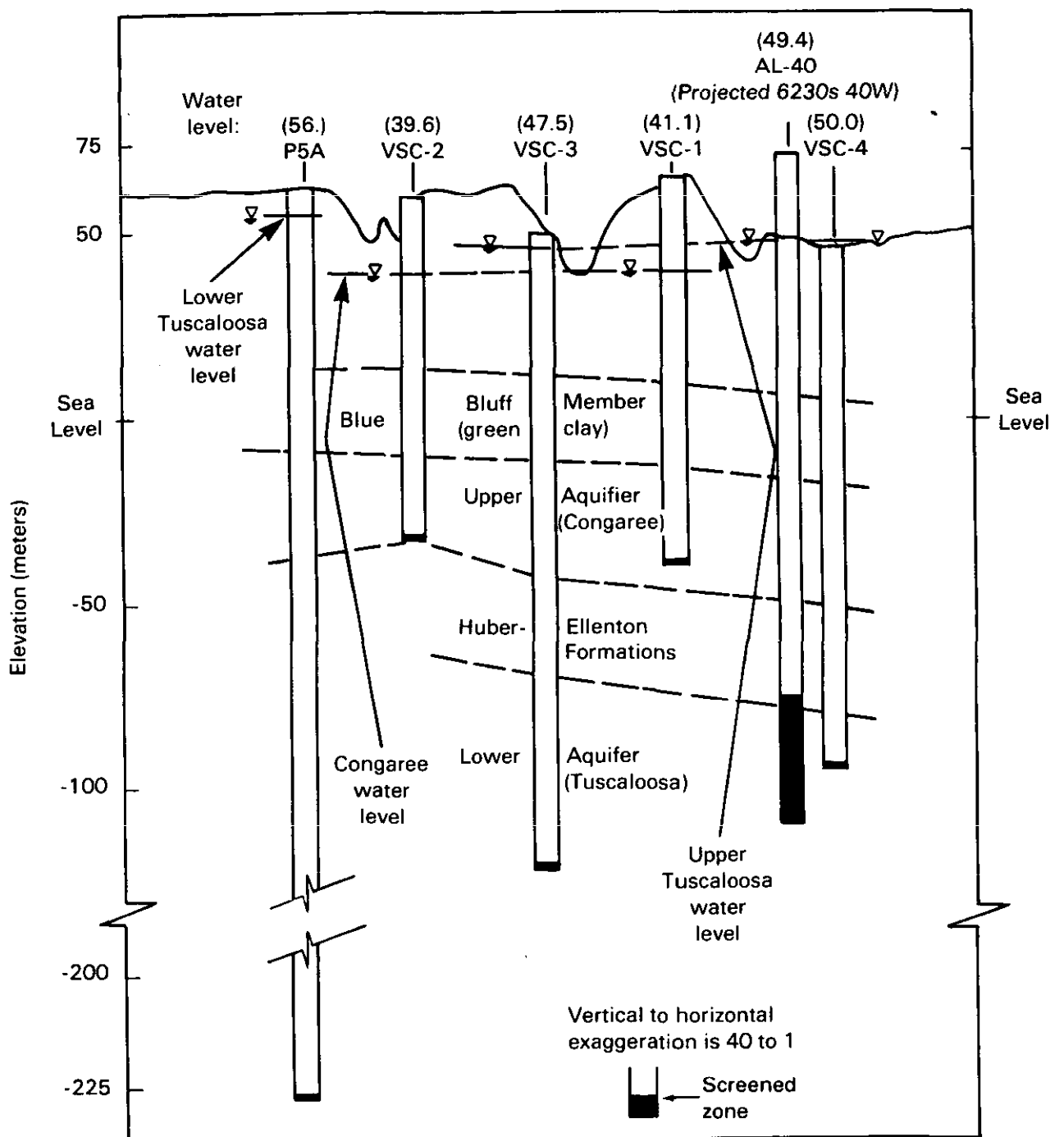
TC

Table F-3. Transmissivity of the Tuscaloosa Formation (Area locations shown on Figure F-6)^a

Location	Transmissivity l/day/m
Savannah River Plant	
A-Area	1.2 x 10 ⁶
C-Area	1.4 x 10 ⁶
F-Area	2.5 x 10 ⁶
H-Area	2.5 x 10 ⁶
K-Area	1.4 x 10 ⁶
L-Area	8.7 x 10 ⁵
P-Area	6.2 x 10 ⁵
R-Area	1.1 x 10 ⁶
Aiken	1.2 x 10 ⁶
Williston	1.5 x 10 ⁶
Barnwell Nuclear	1.8 x 10 ⁶
Fuel Plant	
Average	1.5 x 10 ⁶
Median	1.4 x 10 ⁶

^aAdapted from Marine and Routt (1975).

In addition to showing more detailed stratigraphy at Savannah River Plant, Figure F-5 also shows that the water head in the coastal plain formations in the vicinity of H-Area generally decreases with increasing depth down to the Congaree Formation. This trend indicates some downward movement of water in addition to its horizontal movement. The Congaree Formation crops out in the more deeply incised stream valleys on the plant site, and the water head in this aquifer is controlled in part by the elevation of these on-plant streams. The water head in the Tuscaloosa and Ellenton Formations is higher than in the Congaree Formation (Figure F-5), showing that the Tuscaloosa and Ellenton Formations at SRP are separated from the Congaree Formation by an effective confining layer. Figure F-10 shows the vertical head relationships near the southern boundary of the plant where the water elevation in the Tuscaloosa Formation is also higher than in the Congaree.



Note: See Figure F-4 for correlation between the various formation nomenclature.
Figure F-9 shows the location of this profile.

Source: Du Pont (1983).

Figure F-10. Comparison of ground-water elevations in the Congaree Formation to those in the Tuscaloosa Formation in the southern part of Savannah River Plant (1982).

Figure F-10 also shows that the water elevation in the deep Tuscaloosa aquifer (Middendorf) is higher than that in the shallower Tuscaloosa aquifer (Black Creek) by at least 6 meters. This difference means that care must be exercised in constructing a Tuscaloosa piezometric map. Each aquifer must be mapped separately. Figure F-9 is a piezometric map of the Upper Tuscaloosa aquifer; the water elevations in P5A and P7A (both screened in the deep aquifer) are not shown (they are 7.6 meters and 3.0 meters higher than the shallower Tuscaloosa water elevations at those locations).

TC

Figure F-11 shows the vertical head relationships near M-Area where the Tuscaloosa water elevation is below that of the Congaree. At this location there is a continuous decline of head with depth indicating that this is a recharge area for the Tuscaloosa similar to much of the area of the Aiken Plateau northwest of Savannah River Plant.

In the outcrop area of the Tuscaloosa Formation, hydraulic gradients are steep (0.003) and ground-water velocities are correspondingly high. Down dip where the Tuscaloosa is overlain by a significant thickness of other coastal plain sediments, the gradients are gentler (0.0007) and the velocities are lower. Siple (1967) calculated the horizontal velocity of water of 52.2 meters per year using the hydraulic constants: hydraulic conductivity 4×10^4 liters per day per square meter (40.8 meters per day), a gradient of 0.0007, and an effective porosity of 20 percent.

TC

TC

Ground water is naturally discharged from the Tuscaloosa where the outcrop area is low in elevation, as in the Savannah River and Horse Creek valleys. In these regions, the base flow of streams is supported by discharge from the Tuscaloosa. As shown in Figure F-12, 22 years of pumping about 17 cubic meters per minute at the Savannah River Plant caused no progressive decline in water elevations in the prolific regional Tuscaloosa Formation. Tuscaloosa ground water use and development is discussed in Section F.3.

F.2.3.3 Water quality

Water from the Tuscaloosa Formation is low in dissolved solids (Table F-4). Specific analyses of water from the Tuscaloosa are given in Table F-5. Locations of the sampled wells are shown in Figure F-13. Because the water is soft and acidic, it has a tendency to corrode most metal surfaces (Siple, 1967). This is especially true where the water contains appreciable amounts of dissolved oxygen and carbon dioxide. The dissolved oxygen content of water from the Tuscaloosa Formation around the separations areas is very low (Marine, 1976b), and the sulfate content is about 13 milligrams per liter. The dissolved oxygen content is inversely related to the sulfate content of the water. In the northwest part of SRP nearer the outcrop area, water in the Tuscaloosa is near saturation with dissolved oxygen while the sulfate content is very low.

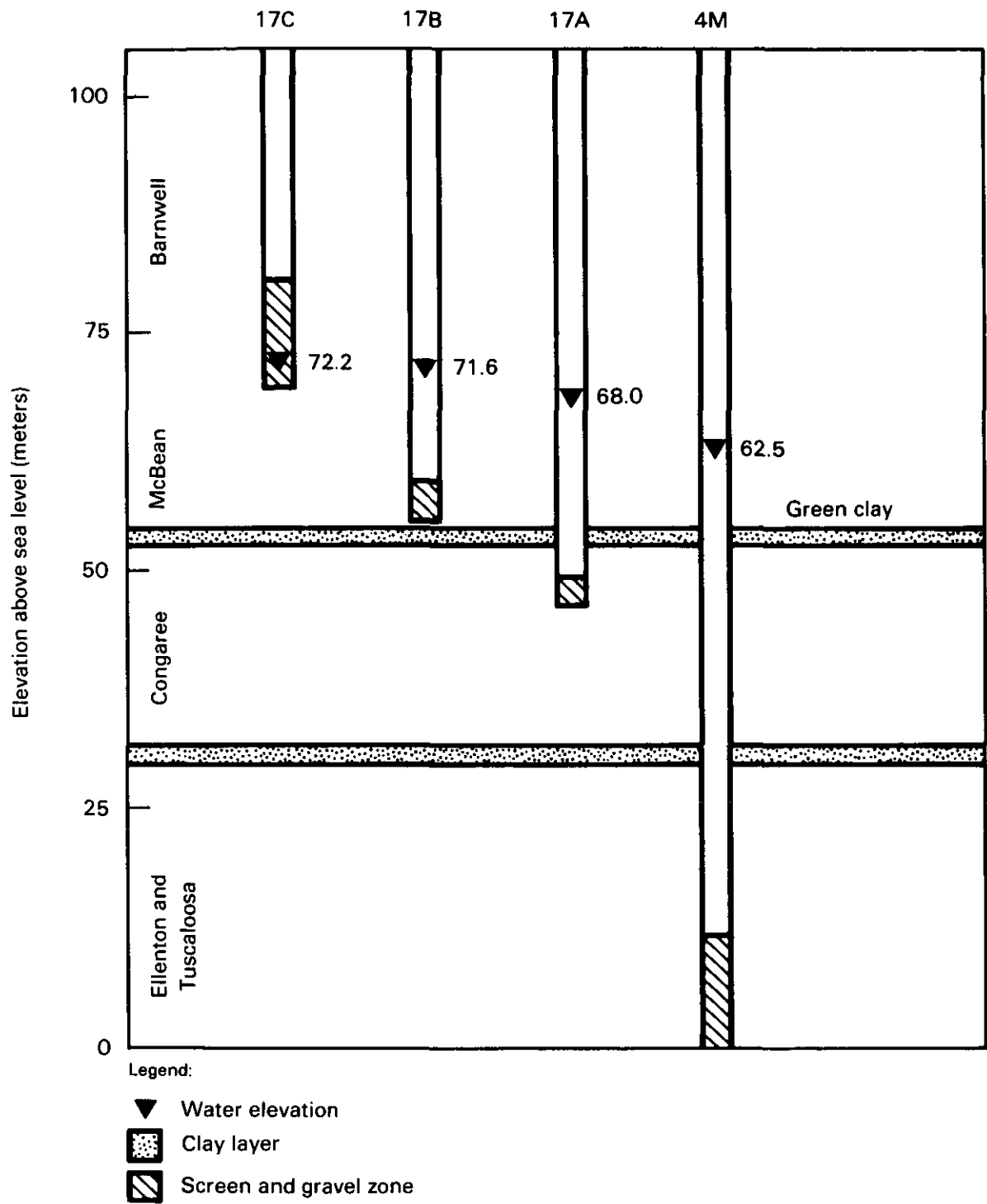


Figure F-36 shows the location of well cluster

Source: DuPont (1983).

Figure F-11. Vertical head relationships near M-Area in 1982.

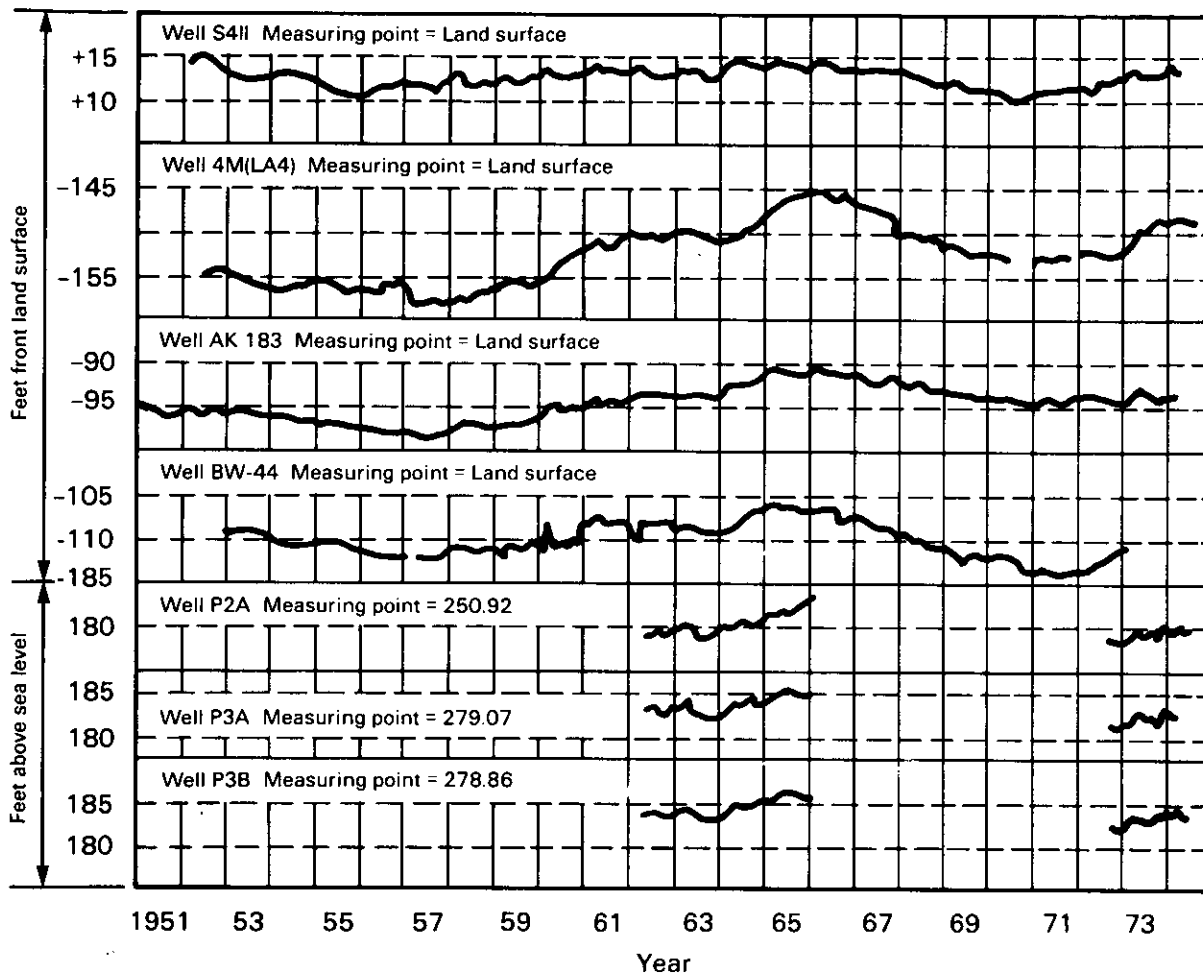


Figure F-9 shows well locations.

TC

Source: Du Pont (1983).

Figure F-12. Long-term hydrographs of water elevations in the Tuscaloosa and Ellenton Formations.

Table F-4. Chemical analyses of ground water from four major sources in the vicinity of SRP^a

Source of water	Number of analyses	Range and median	pH	Constituents, mg/l									Dissolved solids ^b	Hardness ^c
				Fe	Ca ²⁺	Mg ²⁺	Na ⁺ +K ⁺	CO ₃ ²⁻	SO ₄ ²⁻	Cl ⁻	F ⁻	NO ₃ ⁻		
Tuscaloosa Formation	13	Maximum	6.9	0.77	1.4	0.9	6.7	17	4.8	4.0	0.1	8.8	28	7
		Minimum	4.4	0.00	0.3	0.0	0.9	0	0.5	0.8	0.00	0.0	14	2
		Median	5.4	0.16	0.9	0.5	2.1	3	1.4	2.2	0.0	0.6	19	5
Ellenton Formation	16	Maximum	6.8	4.1	8.7	1.3	4.2	23	27	6.0	0.2	0.9	54	30
		Minimum	4.4	0.10	3.9	0.4	1.5	4	7.4	1.5	0.0	0.0	36	10
		Median	5.9	1.1	6.4	1.0	2.7	12	11	2.1	0.1	0.0	41	19
Eocene ^d Limestone	15	Maximum	7.6	1.0	47	9.4	19	17.1	14	4.5	0.5	6.2	192	132
		Minimum	6.8	0.00	17	0.3	0.4	55	0.8	0.4	0.0	0.0	75	50
		Median	7.1	0.25	27	2.0	1.7	94	4.3	2.8	0.1	0.2	95	72
Eocene ^d Sand	9	Maximum	6.1	1.84	8.7	4.2	2.4	17	9.3	4.0	0.3	2.3	29	15
		Minimum	4.2	0.04	0.5	0.3	0.4	1	0.8	1.5	0.00	0	20	4
		Median	5.5	0.16	1.5	0.7	2.1	5.5	1.9	2.7	0.1	1.3	21	8

^aAdapted from Siple (1967).^bResidue after evaporation at 180°C.^cAs CaCO₃.^dMcBean and Congaree Formations.

Table F-5. Analyses of ground water from coastal plain formations at Savannah River Plant^a

Date sampled	Source of water			Properties ^b			Chemical constituents, mg/ ^d															
	Well number ^c	Screen depth, ft	Formation	Temp. °C ^d	pH ^d	Specific conductance, micromhos																
							Ca+2	Mg+2	K+	Na+	Fe	Si	Al	Mn	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻²	NO ₃ ⁻	PO ₄ ⁻³	F ⁻	TDS	
12/16/66	HC1E	43 to 48	Barnwell Upper Zone	21.7	5.8	48	3.3	0.3	1.6	TR ^c	.52	6.8	TR	0.02	12	6.0	1.0	3.8	0.0	0.0	34	
10/25/77	HC2F	74 to 79	Barnwell	23.0	5.04	NM	0.42	0.05	0.10	3.96	<0.2	3.9	<1	<0.02	NM	3.7	0.25	5.8	.32	.01	20	
08/01/74	HC3F	55 to 60	Barnwell	NM	5.2	15	1.7	0.43	0.25	2.9	<0.1	2.9	NM	NM	4.0	3.3	1.0	0.78	NM	NM	15	
10/18/77	HC6B	85 to 90	Barnwell	22.0	6.30	NM	3.72	0.03	1.91	2.20	<0.2	4.6	<1	<0.03	18.3	1.5	0.62	5.1	.01	0.01	30	
07/25/74	HC3E	93 to 98	Barnwell	NM	5.7	18	5.4	0.25	0.54	2.5	<0.1	4.6	NM	NM	16.3	3.0	1.8	<0.0001	NM	NM	26	
07/23/74	HC3D	121 to 126	McBean	NM	4.8	11	0.8	0.37	0.22	1.7	<0.1	5.5	NM	NM	2.1	3.0	1.0	<0.0001	NM	NM	14	
04/28/66	HC2H	134 to 144	McBean Calcareous Zone	23.2	7.1	103	11	0.4	3.0	TR	0.02	12	0.1	0.00	45	4.1	5.8	0.2	0.78	0.01	66	
11/23/77	HC6A	139 to 144	McBean	21.2	6.93	NM	13.8	0.02	0.64	2.57	<0.2	5.4	<1	<0.02	49.3	2.3	0.62	0.05	0.01	0.01	51	
02/21/72	905-72G	110 to 160	McBean	NM	7.0	NM	7.0	9.2	0.90	12.5	0.012	0.60	NM	0.05	27.5	1.6	10.2	0.11	0.18	NM	56	
07/19/74	HC3A	230 to 235	Congaree	NM	6.4	130	28	0.54	0.55	1.5	<0.1	9.4	NM	NM	72	2.8	2.2	0.001	NM	NM	81	
01/19/78	FC2A	231 to 235	Congaree	19.6	6.15	NM	11.1	0.07	0.94	1.45	<0.2	10.7	<1	<0.03	42.7	3.92	10.5	0.05	0.12	0.01	61	
02/21/72	905-31A	440 to 536	Tuscaloosa	NM	5.5	17	0.11	1.7	NM	1.75	0.01	0.56	NM	<0.05	5.4	0.8	2.3	2.3	0.06	NM	10	
02/29/72	905-41D	335 to 490	Tuscaloosa	NM	6.6	NM	1.4	3.5	4.3	11.0	<0.05	0.6	NM	<0.05	9.9	0.59	15.0	15.0	0.3	NM	42	
02/21/72	905-43H	660 to 850	Tuscaloosa	NM	4.3	54	0.82	1.52	1.15	1.82	0.14	0.9	NM	0.05	0.97	0.60	11.3	11.3	--	NM	22	
02/21/72	905-67U	615 to 725	Tuscaloosa	NM	5.15	19	0.22	1.5	0.43	1.6	0.05	0.44	NM	0.05	0.97	0.71	3.5	3.5	--	NM	10	

^aAdapted from Du Pont (1983).^bNM = not measured; TR = trace.^cFigure F-13 shows well locations.^dMeasured at well head.

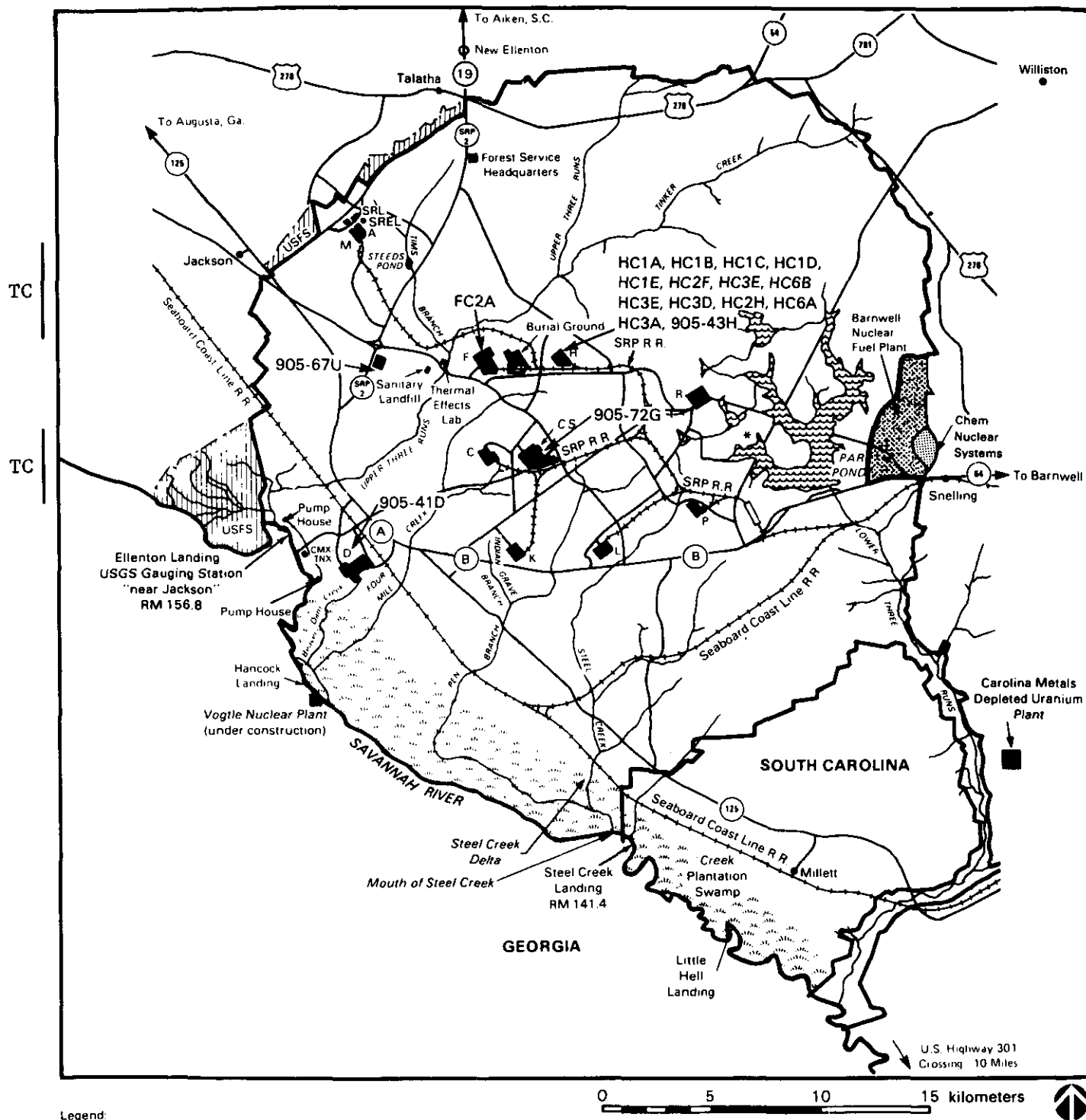


Figure F-13. Locations of wells sampled for chemical analyses of ground water.

F.2.4 Ellenton Formation

F.2.4.1 Hydrostratigraphy

The Ellenton Formation overlies the Tuscaloosa Formation and consists of dark lignitic clay with coarse sand units. It is thought to be Late Cretaceous or Paleocene in age and is unconformably overlain by the Congaree Formation (of the Eocene Epoch). The known Ellenton sediments are entirely within the subsurface; they range in thickness from 0 near the northwest boundary of SRP to about 30 meters southwest of Savannah River Plant.

The Ellenton Formation was described and named by Siple from subsurface studies on the Savannah River Plant (Siple, 1967). The formation was not correlated outside of this area, but Siple speculated that it might be equivalent to the Black Creek Formation of Late Cretaceous age or the Black Mingo Formation of Paleocene or early Eocene age (Siple, 1967).

The lignitic clay is dark gray to black, sandy, and micaceous. It is interbedded with medium quartz sand, and contains pyrite and gypsum. The upper part of the formation is characterized by gray silty-to-sandy clay with which gypsum is associated. This clay is about 3 to 5 meters thick in the central part of SRP; it thickens to 10 meters in the A- and M-Areas, where laboratory measurements indicate that its vertical hydraulic conductivity is 9.8×10^{-5} meters per day. The lower part consists generally of medium-to-coarse clayey quartz sand, which is very coarse and gravelly in some areas (Siple, 1967).

TC

In many places in the vicinity of SRP, there is a thick clay at the top of the Tuscaloosa (Figure F-5) which apparently separates the aquifers of the Ellenton and the Tuscaloosa. However, this clay contains lenses of sand that apparently connect the two aquifers. Although the Tuscaloosa Formation can be differentiated from the Ellenton Formation, the permeable or water-bearing zones within the two formations are not completely separated by an intervening confining bed (Siple, 1967). Since ground water is free to move from one formation into the other where the two formations are hydraulically connected, the permeable zones in the Tuscaloosa and Ellenton Formations are considered to constitute a single aquifer over a large part of the area including Savannah River Plant. The water levels shown in Figure F-5 indicate that this is the case.

F.2.4.2 Hydrologic characteristics

Some of the sand lenses in the Ellenton may be as permeable as sands in the Tuscaloosa, but they are not as thick as the Tuscaloosa sands, and are therefore not developed by wells as commonly as those of the Tuscaloosa. Pumping tests to determine hydraulic constants are rare in the Ellenton Formation. In general, Siple (1967) did not distinguish between the Ellenton and the Tuscaloosa formations in reporting the results of pumping tests. No piezometric map exclusively of the Ellenton Formation exists. Thus, little is known about the lateral flow path of water within the formation. Because it is apparently hydraulically connected to the Tuscaloosa Formation, its flow pattern is probably similar.

Figure F-5 shows the relationship at H-Area of the water elevation in the Ellenton to water elevation in the formations above and below. The water

elevation in the Ellenton is above that in the Tuscaloosa in Figure F-5 because the Tuscaloosa wells are all within the cone of depression of the continuous pumping in H-Area. These Tuscaloosa observation wells are probably more responsive to the hydraulic effects of this local pumping than is the Ellenton well.

The hydraulic heads shown on Figure F-5 indicate that there is not a direct hydraulic connection between the Ellenton and the overlying Congaree Formation. Although the clays that separate the Ellenton and the Congaree are not thick, they are apparently extensive and continuous enough to impede the hydraulic connection. A pisolitic clay at the base of the Congaree appears to be extensive and may constitute the principal confining bed that separates that Congaree and the deeper hydrologic system (Siple, 1967). The upper part of the Ellenton is a sandy clay, which may also function as a confining bed between the Ellenton and the Congaree.

The poor hydraulic connection of the Ellenton with the Congaree and the apparent good connection with the Tuscaloosa can be explained on the basis of the sedimentary environments of these formations. The Tuscaloosa was deposited under nonmarine conditions, and therefore the sands and clays might be discontinuous. The Ellenton was deposited under both nonmarine and estuarine conditions. However, the Congaree was deposited under marine conditions, which would be conducive to deposition of extensive continuous layers of clay and layers of sand.

Because the Ellenton is entirely a subsurface formation, there is no natural discharge to the surface. Water passing through the Ellenton is principally recharged by and discharged to the Tuscaloosa Formation.

Although few wells pump exclusively from the Ellenton Formation, some wells that are screened in the Tuscaloosa are also screened in the Ellenton. Accordingly, the course of future well development in the Ellenton will parallel the development of the Tuscaloosa Formation. It is, however, difficult to estimate the quantity pumped from the Ellenton alone.

F.2.4.3 Water quality

A summary of chemical analyses of water from the Ellenton Formation is given in Table F-4. Its dissolved solids content is somewhat higher than that of water from the Tuscaloosa, but it is still very low at less than 50 milligrams per liter.

F.2.5 Congaree Formation

F.2.5.1 Hydrostratigraphy

The Congaree Formation was included in the McBean Formation by Cooke (1936), and this usage was followed by the U.S. Army Corps of Engineers (COE, 1952) during the original foundation studies for the construction of the Savannah River Plant (Marine and Root, 1978). The lower part of the original McBean was raised to formational status and called the Congaree Formation and

the Warley Hill Marl by Cooke and McNeil (1952). In discussing geology and ground water at Savannah River Plant, Siple (1967) used the term "McBean" both to include all deposits of Claiborne age (see Table F-1) and to include only the upper part of these deposits. In much of the area studied by Siple, the two formations could not be distinguished, either where exposed or in well logs (Marine and Root, 1978).

Subsequent investigations at Savannah River Plant have shown that for hydrologic studies, it is desirable to distinguish the McBean Formation (as used in the restricted sense, rather than as used by Siple, 1967) from the Congaree Formation, because in the central part of Savannah River Plant the water elevation in the Congaree is about 24 meters lower than that in the McBean (restricted sense), and the Congaree is more permeable (Marine and Root, 1978). These two hydrostratigraphic units are separated by a clay layer informally called the "green clay" in studies at Savannah River Plant. This clay occupies the same stratigraphic position as the Warley Hill Marl of Cooke and McNeil (1952).

In discussing the geohydrology, the term McBean Formation will be used only in the restricted sense. The term "deposits of Claiborne age" will be used to refer to the broad sense in which the term "McBean Formation" was previously used (Cooke, 1936).

The deposits of Claiborne age strike about N 60°E and dip at a gradient of about 1.5×10^{-3} to 1.7×10^{-3} toward the south or southeast (Siple, 1967). Their thickness ranges from zero near the Fall Line to about 76 meters in southeastern Allendale County. In the central part of Savannah River Plant, the Claiborne deposits are about 61 meters thick (Figure F-5), of which about 37 meters is Congaree Formation.

In the central part of Savannah River Plant, the Congaree Formation consists of gray, green, and tan sand with some layers of gray, green, or tan clay (Marine and Root, 1978). In the northwest part of Savannah River Plant, it consists primarily of tan clayey sand. It is slightly glauconitic in some places, slightly calcareous in others. In some locations in Calhoun County, South Carolina, it consists of well to poorly sorted sand, fuller's earth, brittle siltstone, and light gray to green shale, alternating with thin-bedded fine-grained sandstone. Elsewhere in Lexington and Calhoun Counties, it includes tan, white, and reddish-brown cross-bedded sand very similar to that in the McBean Formation (Siple, 1967).

Although subdivision of the Claiborne group may be warranted in the SRP area and in other parts of South Carolina and Georgia, such subdivision appears less warranted toward the Fall Line because the shoreward facies of each unit grades into a comparatively thin zone, and criteria for distinguishing them become doubtful (Siple, 1967). That this is so is confirmed by drilling in the northwestern part of Savannah River Plant (M-Area), where the green clay is thin and discontinuous and the sediments of both McBean and Congaree are very similar in appearance.

A pisolitic clay zone at the base of the Claiborne deposits is the base of the Congaree Formation (Siple, 1967). If this characteristic clay is correlative with a similar pisolitic clay zone at the base of the Claiborne deposits on the Gulf Coast, then it is likely that the clay is continuous within the SRP area. This may be the effective confining bed that hydrologically separates the

TC | aquifer in the Congaree Formation from that of the Ellenton Formation. In A- and M-Areas, laboratory tests indicate a vertical hydraulic conductivity of 1.8×10^{-4} meters per day.

TC | The green clay layer at the top of the Congaree Formation appears to be continuous in the central SRP area. In the northwest SRP area (i.e., updip) it becomes discontinuous. This clay is hydrologically significant because it supports a large head differential between water in the McBean Formation above and water in the Congaree Formation below. In the northwest SRP area where the clay is discontinuous, the head differential is not as large. To the south it appears that the green clay thickens to about 7 meters in L-Area and 18 meters in the southeastern portions of the SRP to become what is referred to in Georgia as the Blue Bluff Marl of the Lisbon Formation (Figure F-4). It is encountered at the Vogtle Nuclear Power Station in Georgia, in wells in the southern part of the Savannah River Plant, and offsite to the south. However, intermediate wells that confirm the tentative correlation of the green clay with the Blue Bluff Marl do not exist. The green clay is herein considered to be part of the Congaree Formation even though there is no faunal support for this assignment. This clay consists of gray-to-green, dense, occasionally indurated clay (Marine and Root, 1978). The indurated nature of the clay is commonly caused by dense compaction and siliceous cement. Calcareous cement is usually absent from this indurated zone. Farther south calcareous cement may be more common.

The sand beds of the Congaree Formation constitute an aquifer in this region that is second only to the Tuscaloosa aquifer in productivity. Maximum yields of 2.5 cubic meters per minute with 15 meters of drawdown have been reported from wells in Claiborne deposits on SRP (Siple, 1967). Much of the water produced by high-yielding wells reported to be pumping from the McBean Formation (Siple, 1967) in the broad sense, i.e., Claiborne deposits, probably comes from the Congaree Formation. Another well in these deposits yielded only 0.66 cubic meters per minute with 15 meters of drawdown. Wells in the municipal well field at Barnwell, South Carolina, have yielded as much as 1.5 cubic meters per second with 12 meters of drawdown. However, in other areas such as northwestern SRP (M-Area), the yield may be as low as 0.11 cubic meters per minute with 9 meters of drawdown.

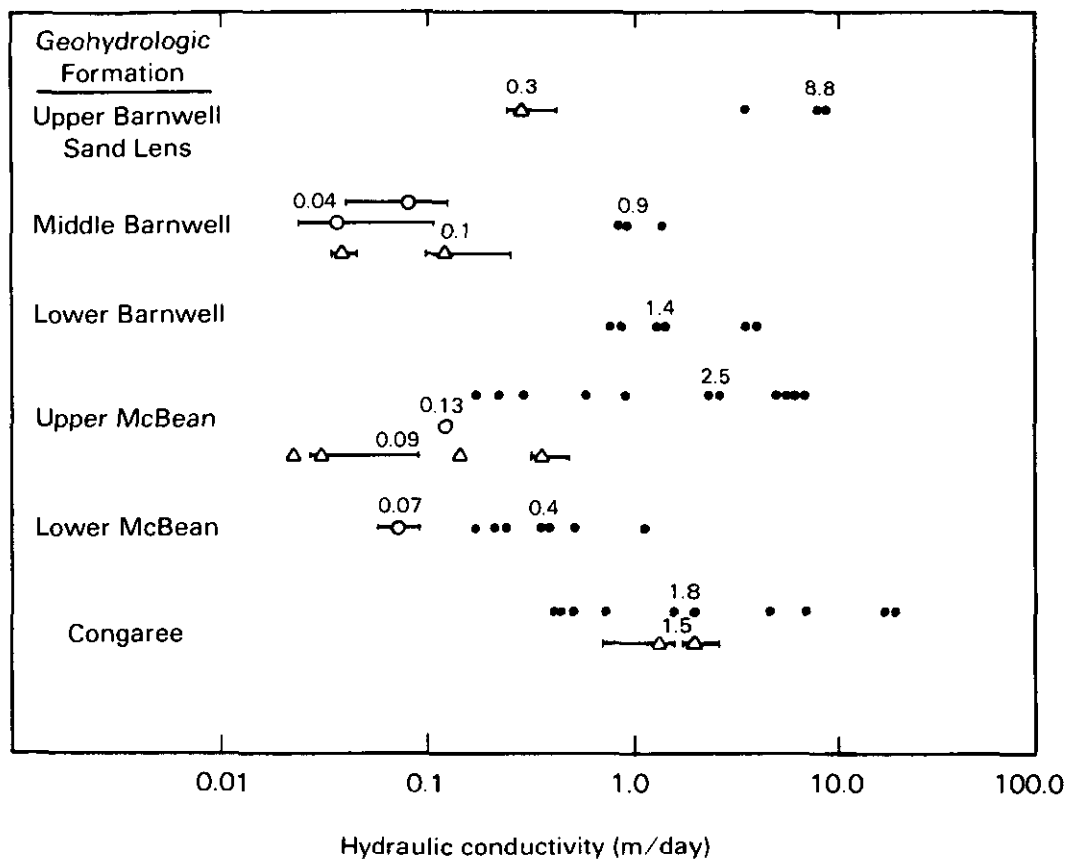
F.2.5.2 Hydrologic characteristics

Table F-6 lists hydraulic constants for the Claiborne deposits. Two of the tests, which were located near the central part of SRP, indicated a hydraulic conductivity of nearly 40,000 liters per day per square meter, whereas one of the values (730 liters per day per square meter) in M-Area is 50 times less than this. The median conductivity value for 10 slug tests (decay of an instantaneous head change) in sandy zones of the Congaree Formation in the separations areas of Savannah River Plant was 1800 liters per day per square meter (Root, 1977a, 1977b). The median conductivity of two water-level recovery tests was 1500 liters per day per square meter. Values for the median hydraulic conductivities for the Tertiary hydrostratigraphic units (Table F-1) in the separations areas determined from aquifer tests are shown in Table F-7. The results of pumping tests, recovery tests, and slug tests on Tertiary units in the separations areas are shown in Figure F-14.

Table F-6. Summary of pumping-test data on the McBean and Congaree Formations^a

Pumping well	Observation well	Date of test	SRP area ^b	Pumping rate (lpm)	Aquifer thickness, (m)	Transmissibility (l/day/m)	Hydraulic conductivity		Storage coefficient
							(l/day/m ²)	Meters per day	
10 TCA	9 TCA	04-16-51	Near C	1540	18	7.3×10^5	4.0×10^4	40	0.0001
14 TSC	14 TC	04-20-51	CS	660	15	8.9×10^4	5.7×10^3	5.8	(c)
26 CY	26 CY	10-18-51	Near P	1550	32	1.2×10^6	3.9×10^4	39	(c)
MPTW-1	MSB11C	06-21-82	Near M	110	18	1.4×10^4	7.3×10^2	0.7	0.14

^aFirst three tests from Siple (1967).^bAreas are shown on Figure F-6.^cNot determined.



Legend:

- Slug tests
- Drawdown tests
- △ Recovery tests
- Range

Note: Median value represented by numbers.

Source: Du Pont (1983).

Figure F-14. Hydraulic conductivity values from selected hydrostratigraphic units.

Table F-7. Median hydraulic conductivities of Tertiary hydrostratigraphic units as determined by pumping tests

Formation	Conductivity ^a (m/day)
Barnwell sand lens	0.3
Barnwell clayey sand	0.04
Barnwell silty sand	--
Upper McBean	0.13
Lower McBean	0.07
Congaree	1.5

^aAdapted from Marine and Root (1976).

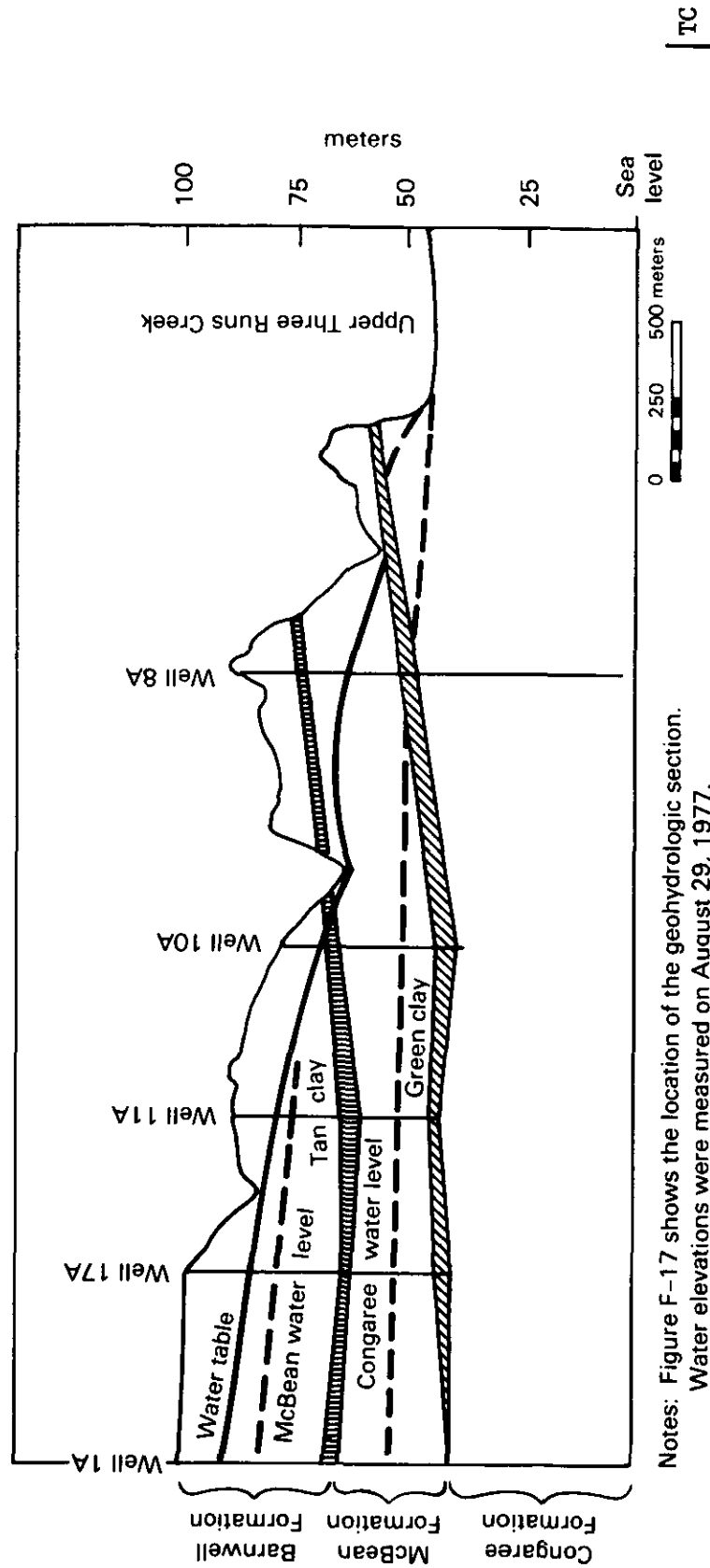
Laboratory tests by the U.S. Army Corps of Engineers (COE, 1952) indicated a median value of 43 percent for the total porosity of the upper part of the Congaree Formation. A reasonable effective porosity (used in calculating ground-water velocity) is estimated as 20 percent. A pumping test in northwest Savannah River Plant gave a value of 14 percent.

Figure F-5 shows the water elevation in the Congaree Formation and its relationship to that in the hydrostratigraphic units above and below. These data are for one location in the separations areas where water-level differences are probably at their maximum. Near the discharge areas of creek valleys, water elevations of the several Tertiary aquifers converge (Figure F-15).

The natural discharge areas for the Congaree Formation at Savannah River Plant are the swamps and marshes along Upper Three Runs Creek and along the Savannah River Valley. Although springs do occur, most of the discharge occurs along the valley bottoms in swamps, making it difficult to measure flow rates of the discharge.

On a regional basis, the dissecting creeks divide ground water in the Congaree Formation into discrete subunits. Thus, even though the hydraulic characteristics of the formation may be similar throughout the area, each subunit has its own recharge area and its own discharge area. If dissection is through most of the formation thickness, then no water moves from one subunit to another.

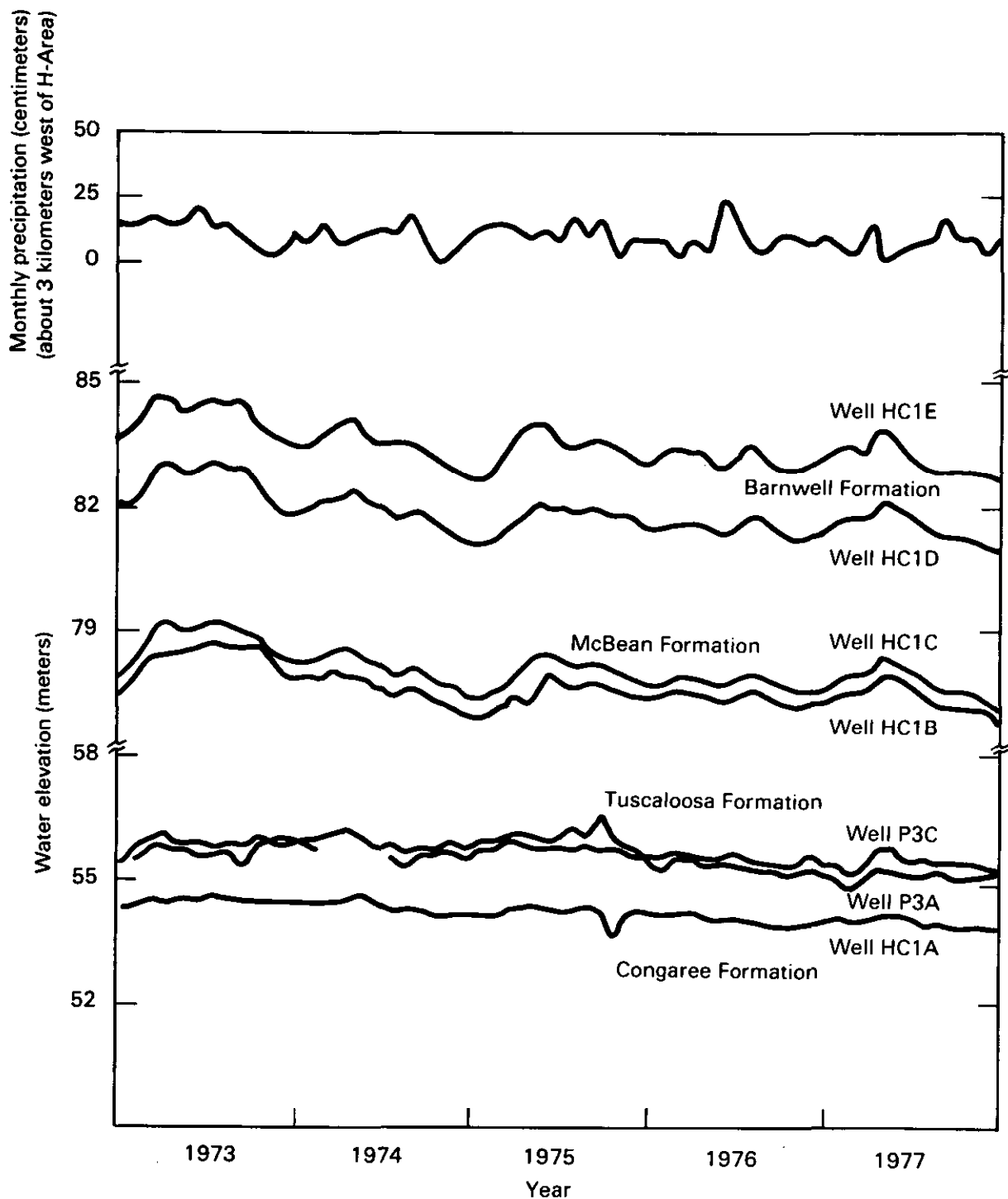
The fluctuation of water elevations in the Congaree Formation and their relationship to those in other hydrostratigraphic units is shown in Figure F-16. The spatial variation of water elevations in the Congaree Formation in the separations areas is shown in Figure F-17. This piezometric map indicates a northwestward movement of water across the separations areas. This direction of movement is governed by the discharge of the water in the Congaree Formation to Upper Three Runs Creek, where the green clay, is breached. Because Four Mile Creek does not breach the green clay, the piezometric map is unaffected by its valley.



Notes: Figure F-17 shows the location of the geohydrologic section.
Water elevations were measured on August 29, 1977.

Source: Du Pont (1983).

Figure F-15. Geohydrologic section in central part of Savannah River Plant.

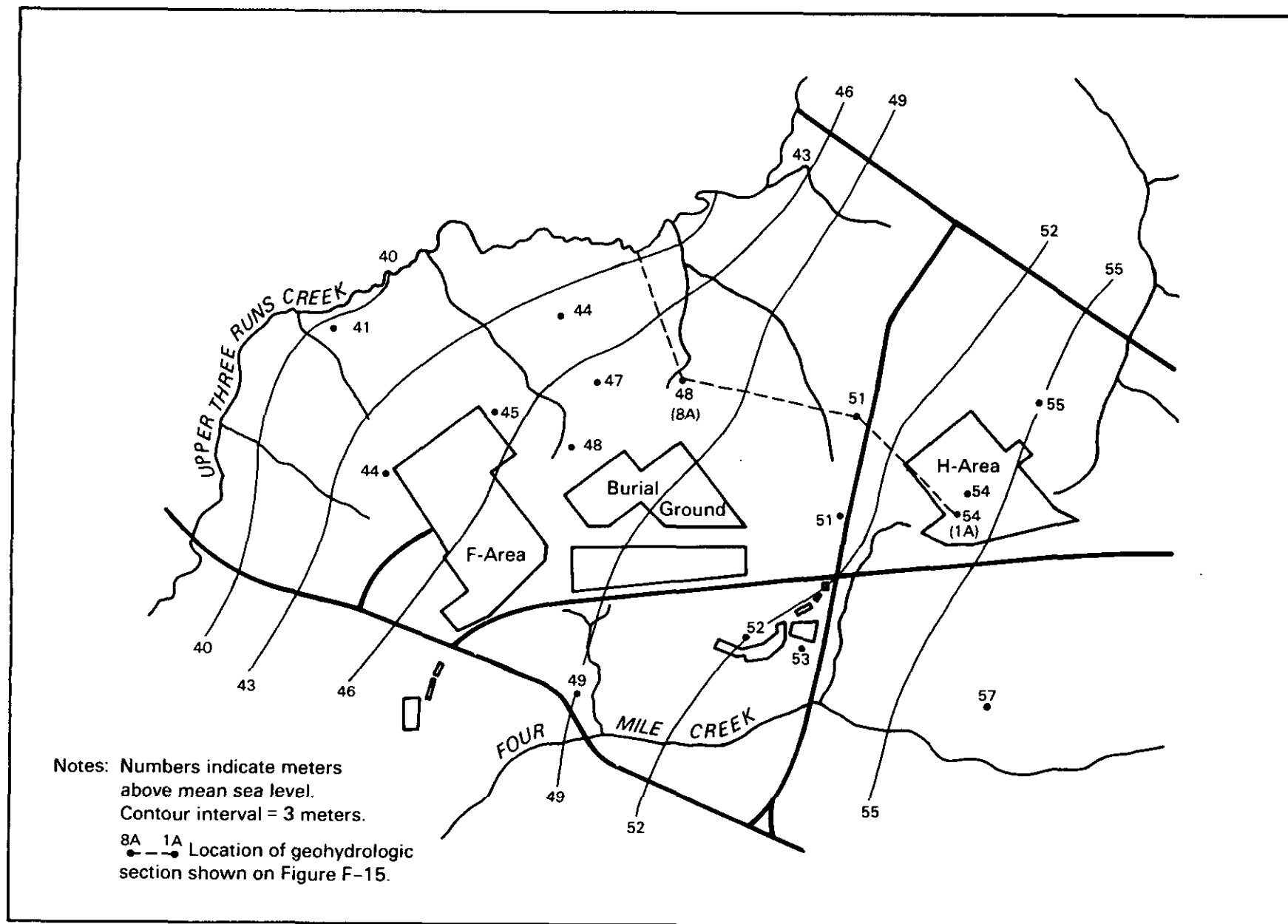


Note: Well locations shown on Figures F-9 (P3A, P3C) and F-13 (HC1A-HC1E).

Source: Du Pont (1983).

TC

Figure F-16. Hydrographs of selected wells and monthly precipitation.



Source: Du Pont (1983).

0 300 600 meters



Figure F-17. Piezometric map of the upper part of the Congaree Formation in the separations areas of Savannah River Plant (August 29, 1977).

As shown in Figure F-18 the water elevations in the Congaree Formation are significantly drawn down by the ground-water discharge to the Savannah River and to Upper Three Runs Creek. Two regional piezometric maps of the Congaree have been recently published (Faye and Prowell, 1982; Georgia Power Company, 1982), but neither reflects the significant drawdown due to the incision of the formation by Upper Three Runs Creek.

The vertical head relationships of the Congaree to the units above and below are shown in Figures F-5, F-15, and F-16. These figures show that the head in the Congaree Formation in the separations areas is the lowest of any hydrostratigraphic unit in the coastal plain system. This is brought about by two factors: (1) the low permeability of the green clay through which recharge must take place, and (2) the high hydraulic conductivity of the Congaree sands below the green clay, which enhances lateral movement and discharge to the deeper creek valleys. Upward recharge of water to the Congaree from the Ellenton-Tuscaloosa systems is also impeded by clay layers at the base of the Congaree and at the top of the Ellenton.

The lateral hydraulic gradient, I , in the Congaree Formation (Figure F-18) ranges from about 0.003 to 0.005. Using a hydraulic conductivity, K , of 1.5 meters per day (Table F-7) and an effective porosity, j , of 20 percent, the flow velocity (Darcy's Law) is

$$v = \frac{IK}{j} = \frac{365 \text{ days/yr} \times 0.005 \times 1.5 \text{ m/day}}{0.20} = 13.7 \text{ m/yr}$$

In the A- and M-Areas, the lateral flow velocity is about 3.2 to 7.6 meters per year; in the southern part of the Plant, the velocity is calculated to be 160 meters per year. | TC

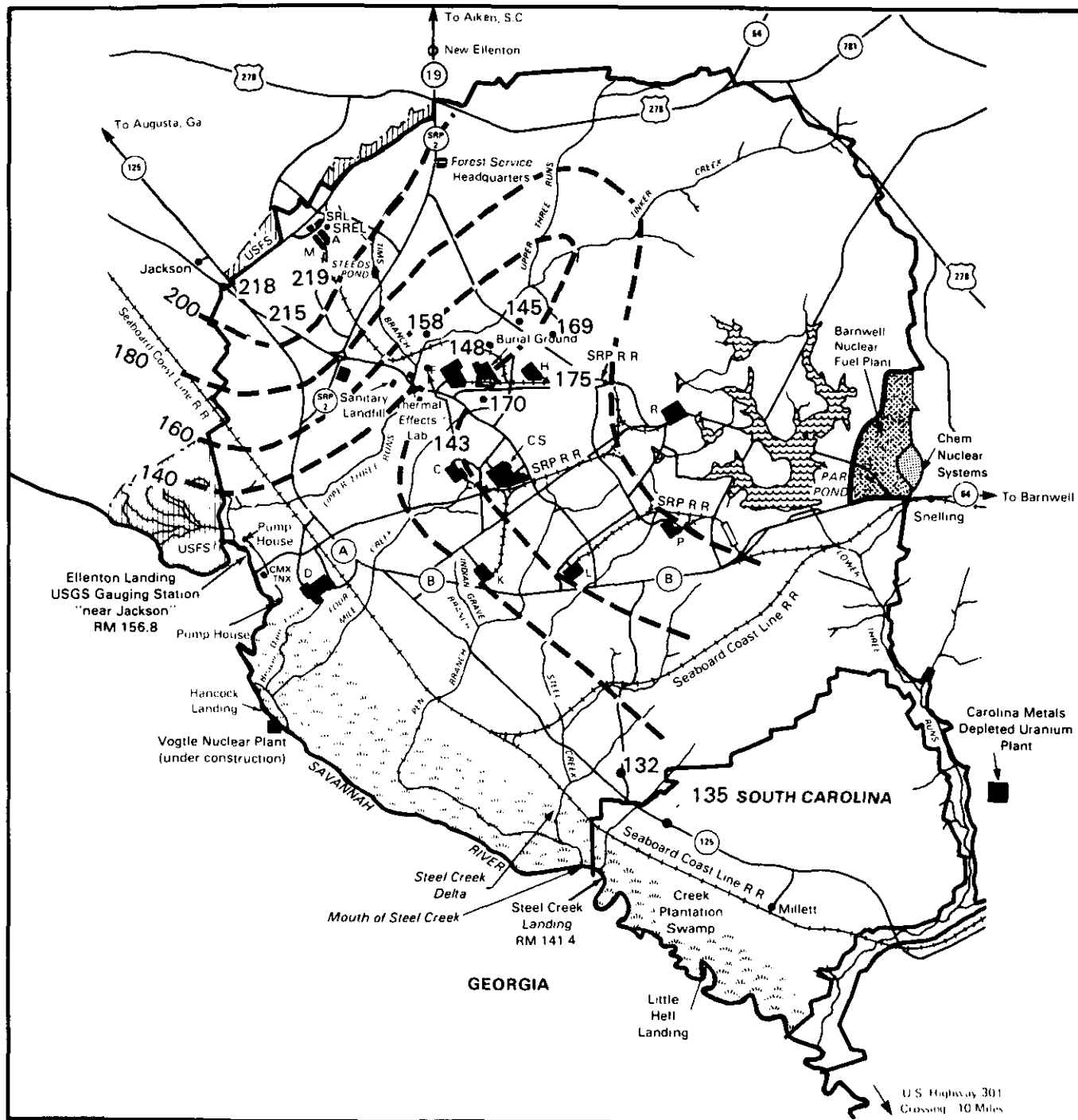
The Congaree Formation provides water to Savannah River Plant (tens to hundreds of liters per minute) and to the rural population around Savannah River Plant. In the M-Area vicinity the Congaree Formation is clayey sand rather than sand as it is farther downdip. Thus well yields in this area are not nearly as high as in the downdip areas. For example, a hydraulic conductivity value of 730 liters per day per square meter in M-Area (Table F-6) is only 2 percent of the value of 40,000 liters per day per square meter obtained from pumping tests near C-Area and P-Area. In the future, pumpage will increase from both the Congaree and Tuscaloosa Formations, but increases are expected to occur more rapidly in the Tuscaloosa.

F.2.5.3 Water quality

Summary of chemical analyses of water from deposits of Eocene age (McBean and Congaree Formations) is given in Table F-4 as reported by Siple (1967). These analyses are grouped into those from Eocene limestone, which would be primarily for water from the McBean Formation but might include some analyses of water from the Congaree Formation, and those of water from Eocene sand, which would include the Barnwell, McBean, and Congaree Formations.

The analyses of water from the Eocene sands are similar to those from the Tuscaloosa Formation, which is also predominantly sand. The water is low in

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Legend:

- C, K, R, L, P Reactor Areas (C, P, K are operating)
- F, H Separations Areas
- M Fuel and Target Fabrication
- D Heavy Water Production
- A Savannah River Laboratory and Administration Area
- CS Central Shop
- RM River Mile

Road A = Highway 125

Note: Contours and water levels in feet above mean sea level.
1.0 foot = 0.3048 meter.

Source: Du Pont (1983).

Figure F-18. Piezometric map of the Congaree Formation (May 11, 1982) at Savannah River Plant.

dissolved solids (about 20 milligrams per liter) and is acidic (pH about 5.5). In comparison, the water from the Eocene limestone is much higher in dissolved solids (about 100 milligrams per liter) and is nearly neutral (pH about 7). Most of the increase in dissolved solids is due to increases in calcium and bicarbonate ions, as would be expected from sediments high in calcium carbonate.

Two analyses of water from sands in the Congaree Formation are shown in Table F-5. The analyses are similar to those reported for Eocene limestone by Siple (1967), including a high calcium and bicarbonate content. These zones in the Congaree Formation probably contained some calcareous cement, giving rise to the ionic content of this water.

F.2.6 McBean Formation

F.2.6.1 Hydrostratigraphy

As previously discussed, the term McBean was originally used to designate all deposits of Claiborne age in this area, but it is now used to designate only the upper part of these sediments. Even though this distinction was originally made on a stratigraphic basis, the distinction is even more significant on a hydrologic basis. Hydraulic head differences between the McBean and Congaree Formations are large in many places, and the Congaree is about 10 times more permeable than the McBean.

The McBean Formation may be divided into two subunits, an upper unit consisting of tan clayey sands and occasionally red sand (Marine and Root, 1978), and a lower unit consisting of light tan-to-white calcareous clayey sand. This lower unit is locally referred to as the "calcareous zone"; in some places, it contains void spaces that could result in rod drops or lost circulation during drilling operations (COE, 1952). To the northwest these void spaces appear to decrease so that no calcareous zone exists in the northwest part of Savannah River Plant (M-Area). However, to the southeast the lime content of the zone increases as do void spaces. Southeast of Savannah River Plant the zone becomes a limestone with only small amounts of sand; and its water yielding potential increases.

The McBean Formation is considered to be the shoreward facies of the Santee limestone, which occurs to the southeast (Siple, 1967). In the SRP area, the "calcareous zone" may represent a tongue of the Santee limestone. Toward the Fall Line to the northwest of SRP, it becomes more difficult to distinguish the several Eocene formations, and Siple (1967), maps the Eocene deposits undifferentiated. In the northwest SRP area (M-Area), the calcareous zone is replaced by a clayey sand unit.

Ground water occurs in both the upper sandy unit and in the calcareous zone, but neither are prolific aquifers in the central part of SRP. Farther to the southeast, where the calcareous content as well as the number and size of the voids in the calcareous zone increase, well yields are moderate.

As with the Congaree Formation, creeks in the region dissect the McBean Formation, and divide the hydrogeologic unit into separated subunits, each having its own recharge and discharge area. Because the McBean is a shallower

formation than the Congaree, smaller creeks with less deeply incised valleys make these divisions. The subunits of the McBean are therefore smaller than those of the Congaree. In the separations areas, the only stream that cuts into the Congaree is Upper Three Runs Creek, whereas the McBean is incised by Upper Three Runs Creek, several of its larger tributaries, and Four Mile Creek. Thus, ground water that enters the McBean Formation in the separations areas cannot migrate to other subunits of the McBean.

F.2.6.2 Hydrologic characteristics

The median hydraulic conductivity of the upper sand of the McBean Formation is 130 liters per day per square meter (0.13 meters per day) and that of the calcareous zone is about half that of the upper sand (Table F-7). Figure F-14 shows the median and range of hydraulic conductivity as measured in the field by slug tests, recovery tests, and drawdown tests. Figure F-19 shows the range and median of laboratory measurements of hydraulic conductivity. An effective porosity of 20 percent is presumed reasonable.

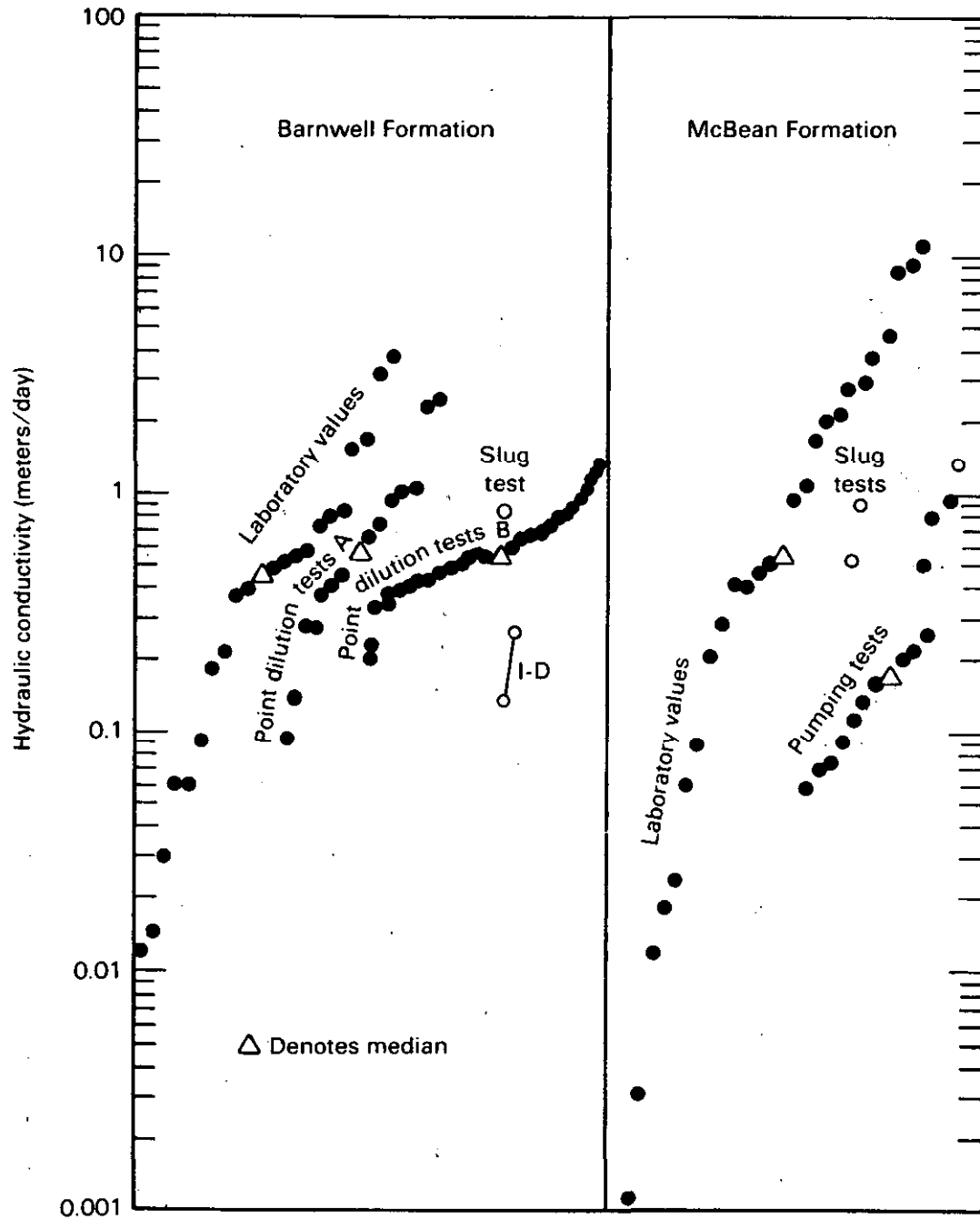
Fluid losses in the calcareous zone during drilling operations make it appear very permeable. However, pumping tests on the calcareous zone indicate a low hydraulic conductivity (Table F-7, Figure F-14). Apparently zones of higher permeability do not connect over large distances, and the regional permeability of the calcareous zone is lower than it appears from drilling experience.

Water elevations in both the upper sand unit and in the calcareous zone are shown in Figures F-5 and F-16. These data, based on wells in the recharge area, indicate a difference of about 0.6 meter in hydraulic head between the top of the McBean and its base. This indicates a better hydraulic connection between the sandy unit of the McBean and the calcareous zone than between the McBean and the Congaree Formations below or the Barnwell Formation above.

Figure F-20 shows the piezometric surface of the upper part of the McBean Formation in the separations areas. This map indicates lateral flow in the upper part of the McBean Formation toward Upper Three Runs Creek to the north and toward Four Mile Creek to the south. Because of the hydraulic connection between the upper sandy zone and the calcareous zone, Figure F-20 can also be used to determine the approximate flow path of water in the calcareous zone.

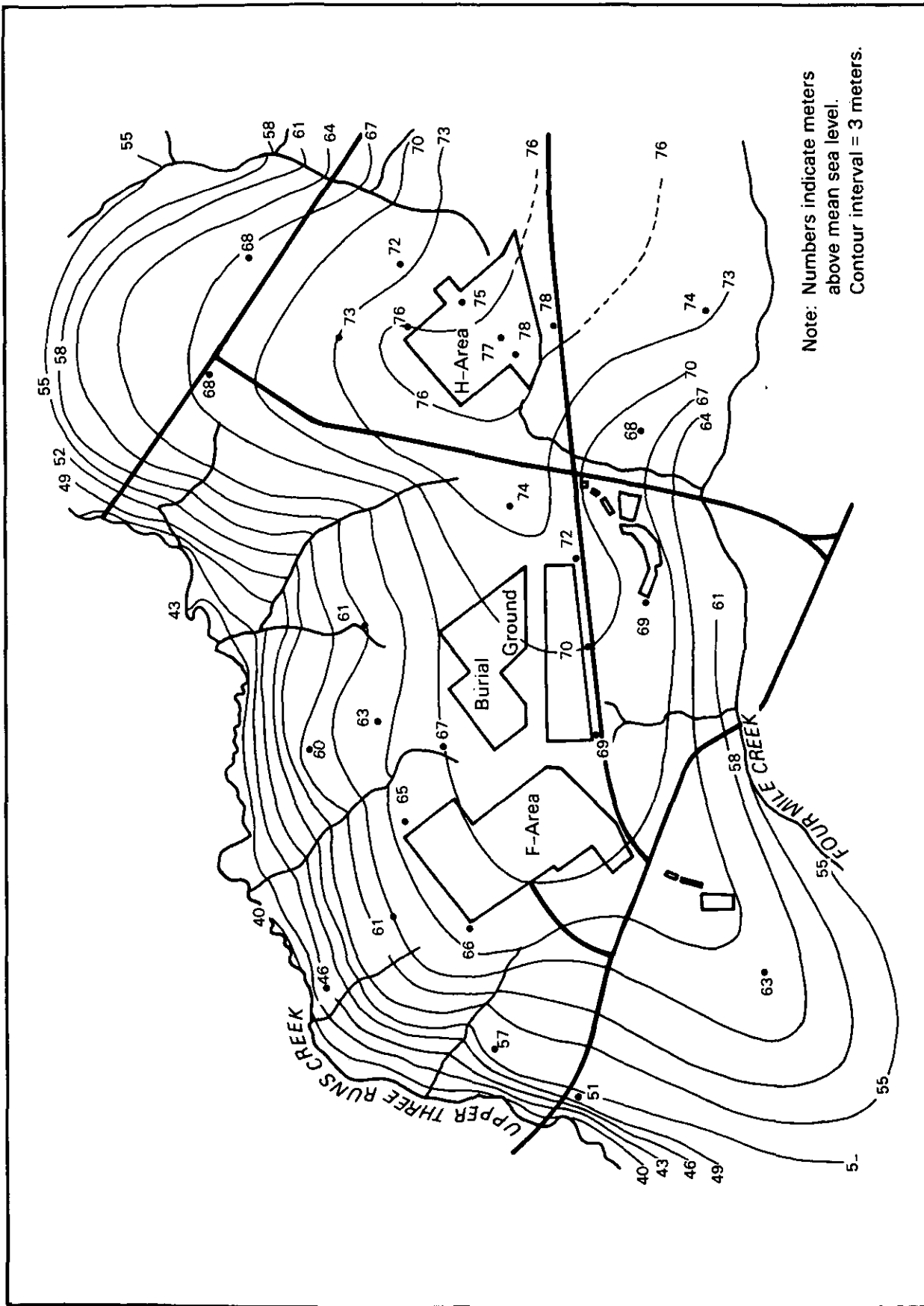
As previously described, the green clay impedes downward movement of water from the McBean to the Congaree Formation in the central part of Savannah River Plant, thereby contributing to a hydraulic head differential of about 24 meters (Figure F-5). In the Barnwell Formation just above the McBean Formation, a tan clay impedes vertical movement of water from the Barnwell Formation into the McBean. This tan clay is not as continuous as the green clay, and it has a higher hydraulic conductivity. The McBean Formation is less permeable than the Congaree; thus, the head differential between the Barnwell and the McBean Formation is only about 4 meters (Figure F-5).

Using the previously given hydraulic conductivity, and effective porosity along with an appropriate hydraulic gradient of 0.017, the average horizontal velocity of the McBean in the central part of Savannah River Plant is calculated (by Darcy's Law, as was done for the Congaree) as 4.0 meters per year. Assuming



Source: Du Pont (1983).

Figure F-19. Horizontal hydraulic conductivities of the Barnwell and McBean Formations in the separations areas at Savannah River Plant.



Source: Du Pont (1983).

Figure F-20. Piezometric surface of the upper part of the McBean Formation in the separations areas at Savannah River Plant (August 29, 1977).

the same gradient as for the Upper McBean, the regional ground-water velocity in the calcareous zone is 2.2 meters per year.

In the northwest part of Savannah River Plant (M-Area) the average hydraulic conductivity of the McBean and Congaree Formations together, as determined from a pumping test, is 0.75 meter per day and the average velocity is about 6.1 meters per year. The main body of the chlorinated hydrocarbon plume in the A- and M-Areas is moving at a rate of 7.6 meters per year; the outer fringe is moving at 76 meters per year.

TC

Water from the McBean Formation is not used for industrial or municipal purposes. Larger wells producing from the Claiborne deposits probably derive most of their water from the Congaree. The McBean is, however, sufficiently permeable in some places to supply water for domestic use.

Because the McBean Formation is not used for large supplies of water, it is not anticipated that there will be much future change from water use in the hydrologic regimen of this formation. The head differential between the McBean and Congaree is about 24 meters at present, and even if the Congaree were subjected to additional drawdown, it is unlikely that there would be much effect on the McBean hydrology. Dissection of the McBean by local creeks also divides the formation into subunits whose hydrologic regimen is unaffected by adjacent subunits. Thus, increased development in one of the subunits would have little effect on the regional hydrology of this formation.

F.2.6.3 Water quality

Samples of water from Eocene sand and Eocene limestone probably include some water from both the upper sand and the calcareous subunits of the McBean Formation. The median and range of chemical analyses are listed in Table F-4. The water from both subunits is low in dissolved solids, but water from the upper sand subunit is much lower. The differences in the chemical characteristics of water from the two subunits of the McBean are readily apparent in Table F-5. Well HC3D in the upper sandy unit has a total dissolved solids content of 14 milligrams per liter with all constituents being very low. The other two wells are screened in the calcareous zone and have a dissolved solids content of more than 50 milligrams per liter with higher calcium and bicarbonate contents. The pH of the water from the calcareous zone is near 7, while that of water from the upper sandy zone is generally less than 5.

F.2.7 Barnwell Formation

F.2.7.1 Hydrostratigraphy

The Barnwell Formation directly overlies the McBean Formation and is exposed over a considerable area in the uplands of Aiken and Barnwell Counties. The formation thickens to the southeast from zero in the northeastern part of Aiken County to about 27 meters at the southeast boundary of Barnwell County. The Barnwell Formation is overlain by the Hawthorn Formation, from which it is

usually difficult to distinguish from the Barnwell. In the separations areas, these two units together are usually about 30 meters thick (Figure F-5).

The Barnwell Formation consists mainly of deep red fine-to-coarse clayey sand and compact sandy clay. Other parts of the formation contain beds of mottled-gray or greenish-gray sandy clay and layers of ferruginous sandstone that range in thickness from 0.03 to 1 meter. Although fossils at some places indicate a marine origin, material identified as Barnwell may have been deposited in other places as alluvium during Pliocene to Pleistocene time (Siple, 1967). Beds of limestone occur in the Barnwell Formation in Georgia, but none have been recognized in South Carolina.

These factors indicate that a considerable part of the Barnwell Formation was deposited as a sandy limestone in a near-shore or estuarine environment. Some evidence of the remnant calcareous nature of the formation is indicated by the comparatively high proportion of calcium carbonate found in ground water circulating in this unit (Siple, 1967).

In the separation areas, the Barnwell Formation appears divisible into three parts:

1. The lowest unit, the tan clay, commonly consists of two thin clay layers separated by a sandy zone. The entire unit is about 3 to 4.5 meters thick and is semicontinuous over the area.
2. Above the tan clay is a silty sand unit, 0 to 12 meters thick.
3. Above the silty sand is a unit of clayey sand (that may include beds of silty clay or lenses of silty sand) to 30 meters thick. This sand is slightly less permeable than the underlying silty sand.

Because of the large amount of clay and silt mixed with the sands, the Barnwell Formation does not generally yield water to wells. However, an occasional lens of sand may be relatively free of clay and can provide adequate quantities of water for domestic use.

F.2.7.2 Hydrologic characteristics

Laboratory measurements of hydraulic conductivities of many undisturbed Barnwell samples, as well as results of point-dilution tracer tests, are shown in Figure F-19. The median conductivity was 0.04 meter per day for the clayey sand unit (Table F-7 and Figure F-15). Although no pumping tests were made on the silty sand unit, a pumping test in a sand lens within this unit indicated a hydraulic conductivity of 0.3 meter per day (Table F-7).

The relationship of water elevations in different zones within the Barnwell, as well as the relationship of these levels to those in the formations below, are shown in Figures F-5 and F-15. The variations of water levels in the Barnwell over a period of five years are shown in Figure F-16. This figure indicates that the amplitude of water elevation fluctuation is greater in the Barnwell than in the formations below.

Figures F-5 and F-15 show a hydraulic head that decreases with depth within the Barnwell Formation. Although the tan clay impedes the downward movement of water, the McBean Formation is recharged by water that passes through this hydrostratigraphic unit.

The water table is commonly within the Barnwell Formation, although in the creek valleys it successively occupies positions in the lower formations (Figure F-15). A map of the elevation of the water table is shown in Figure F-21. The surface drainage and topography strongly influence the flow path at any point. Even small tributaries to the larger creeks cause depressions in the water table, diverting ground-water flow towards them.

Using an overall average gradient for the water table of 0.018, a hydraulic conductivity for the clayey sand unit of 0.04 meter per day (Table F-7), and an effective porosity of 20 percent, the ground-water velocity through Barnwell material is calculated as 1.3 meters per year. If a sand lens with a hydraulic conductivity of 0.3 meter per day (Table F-7) existed for the entire flow path, the velocity would be 9.7 meters per year. A series of tracer dilution tests and tracer injection detection tests yielded velocities ranging from 0.7 to 21 meters per year (Fenimore, 1968).

Natural discharge from the water table, which is predominantly in the Barnwell Formation, is to the creeks and their tributaries on Savannah River Plant. The areas of perennial creek drainage are shown by the solid lines representing creeks in Figure F-21.

The Barnwell Formation supplies water for domestic purposes in some places in the region, but it is not used by industry or municipalities. Total pumpage has not been estimated, but is small. The future ground-water levels of the Barnwell Formation will mainly depend on natural conditions such as rainfall.

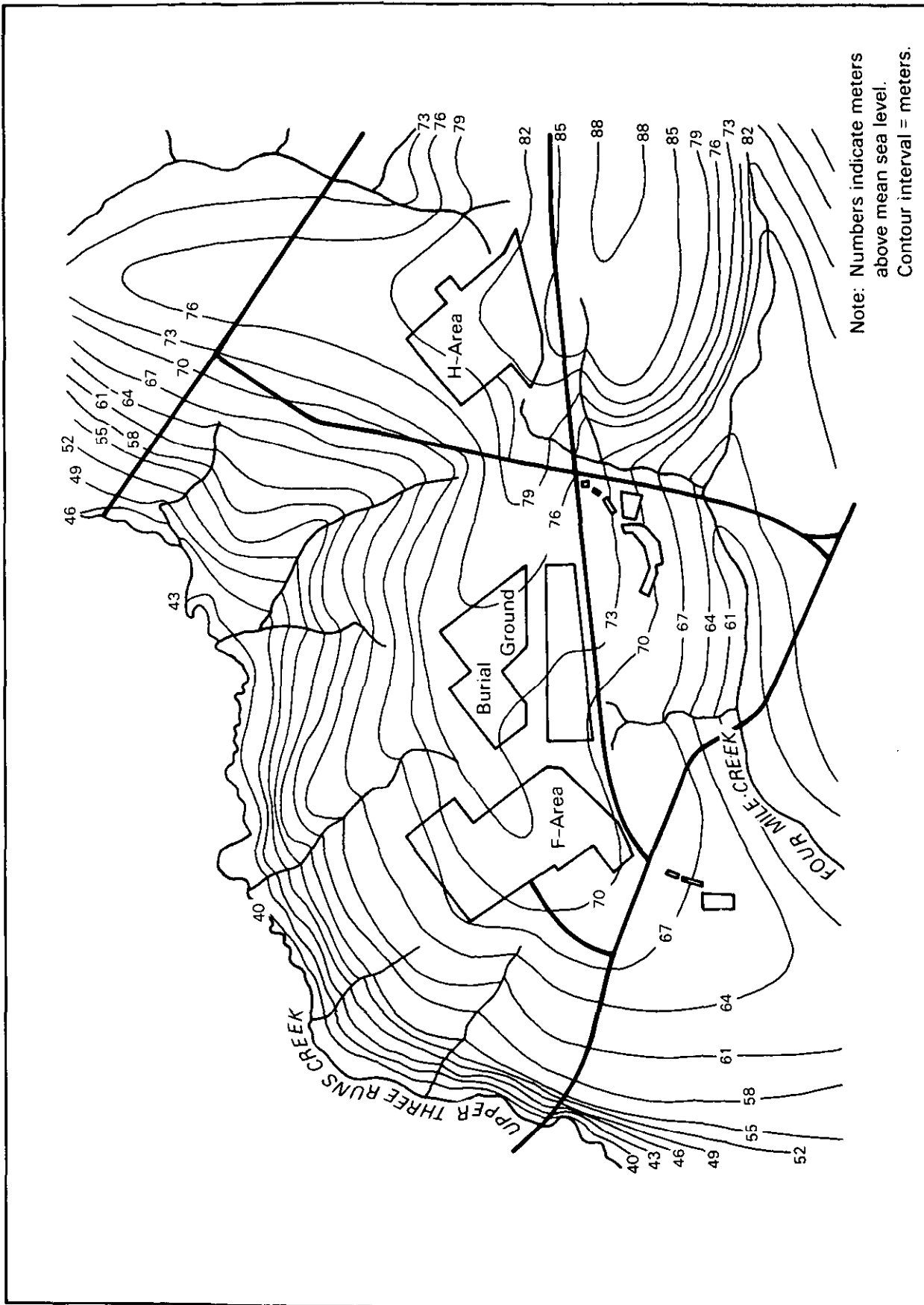
F.2.7.3 Water quality

Five analyses of water from the Barnwell Formation in the separations areas are given in Table F-5. The dissolved solids content is low, and the calcium and bicarbonate ions are not as high as in the McBean and Congaree Formations. The pH of water from the Barnwell Formation is as low as that of water from other formations in the area.

F.2.8 Hawthorn Formation

F.2.8.1 Hydrostratigraphy

The Hawthorn Formation crops out over a very large area of the Atlantic Coastal Plain and is perhaps the most extensive surficial deposit of Tertiary age in this region (Siple, 1967). It is bounded on top and bottom by erosional unconformities, and is present at the surface in the higher areas of Aiken County. It ranges in thickness from zero in northwestern Aiken County to about 25 meters near the Barnwell-Allendale County Line.



Source: Du Pont (1983)

Figure F-21. Average elevation of the water table in the separations areas at Savannah River Plant during 1968.

Typical Hawthorn Formation is fine, sandy, phosphatic marl or soft limestone and brittle shale resembling silicified Fuller's earth. Updip, however, in the vicinity of Aiken and Barnwell Counties, it is characterized by tan, reddish-purple, and gray sandy, dense clay that contains coarse gravel, limonitic nodules, and disseminated flecks of kaolinitic material.

The fine-grain materials within the Hawthorn Formation, consisting of compact silt and clay, are incapable of yielding water and are therefore not suitable for wells (Siple, 1967). The Hawthorn Formation is above the water table throughout much of the SRP area. However, where low permeability beds are overlain by more permeable beds, perched water bodies may occur.

F.2.8.2 Hydrologic characteristics

Because the Hawthorn Formation in the SRP area is usually unsaturated, no pumping tests have been performed. There is no piezometric map of the Hawthorn Formation in this area. Flow paths are predominantly vertical, with only short horizontal flow paths.

Within the Hawthorn there are numerous clastic dikes that criss-cross the clayey sand of the formation. These dikes are generally filled with greenish-gray silty-to-sandy clay (Du Pont, 1980). The dike wall, 0.5 to 2.5 centimeters thick, is generally indurated and consists of an iron oxide-cemented quartz sand (Siple, 1967). Thus, the dike filling is generally finer grained than the surrounding sediments. The origin of the dikes is uncertain. Possible explanations include (1) shrinkage resulting from weathering, (2) seismic activity, and (3) relief of compressional stresses by upward movement of plastic material (Siple, 1967).

F.2.8.3 Water quality

No water samples from the unsaturated zone have been analyzed.

F.2.9 Surficial formations

F.2.9.1 Tertiary alluvium

Alluvial deposits of Late Tertiary age occur irregularly and discontinuously on the interstream divides or plateaus. They are composed of coarse gravel and poorly sorted sand and were tentatively classified by Siple (1967) as Pliocene in age. Their thickness ranges from 1.5 to 6 meters. These deposits are generally considerably above the water table and are therefore unimportant as a source of ground water for wells. Nevertheless, they are fairly permeable, and are capable of storing and transmitting water. Their presence therefore enhances recharge to underlying formations.

F.2.9.2 Terrace deposits

Cooke (1936) recognized seven marine terraces of Pleistocene age on the Atlantic Coastal Plain of South Carolina. He indicated that the four highest terraces are present in the Savannah River Valley. The deposits that may be associated with these terraces are on the order of 10 meters thick or less (Cooke, 1936). Because of their near-surface location, they are not important as sources of well water.

F.2.9.3 Holocene alluvium

Alluvium of Holocene age occurs in the tributary and main channels of the Savannah River. These deposits, which are generally cross-bedded and heterogeneous in composition, range in thickness from 1.5 to 9 meters (Siple, 1967). The poorly sorted sand, clay, and gravel have little potential for ground-water development except along the larger streams where infiltration galleries might be possible.

F.2.10 Hydrostratigraphy at L-Area

TC | The hydrostratigraphy at L-Area can be developed from the regional hydrostratigraphy as well as geological investigations and well logs at L-Area. Figure F-22 shows a hydrostratigraphic section from Pen Branch to Steel Creek developed from foundation borings (COE, 1952) and the driller's log from one of the water wells (29-L). Figure F-23 shows two cross sections through L-Area down to an elevation of about 12 meters above sea level. The tan clay is not readily evident from foundation borings, drillers logs, or geophysical well logs; however, even in other areas of the Savannah River Plant where it supports a significant head difference, this clay is not always apparent in soil cores alone. The calcareous zone is quite evident as it should be in this downdip location where the original lime content of the zone was greater. The green clay is recognizable in the water well driller's log, but cores might indicate that it is thicker than shown in the driller's log. Based on self-potential, resistivity, and gamma-ray geophysical well logs of wells 104L and 55-2, the green clay is 7 meters thick. (Figure F-24 shows the areas of the well field.) TC | The Congaree Formation is not distinctive on the driller's log, but the upper aquifer of the Tuscaloosa Formation is noted in logs.

EN-44 | Figure F-24 is a water table map in the vicinity of L-Area. The water table in this area is unaffected by plant pumpage and is subject only to variation in local precipitation. The water table is between 3 and 6 meters below the surface (60 to 75 meters above sea level). The water table has a gradient of approximately 0.0188 (including the head of water in the seepage basin), resulting in lateral flow from the seepage basin toward Steel Creek. If the hydraulic conductivity of the Barnwell (water table) Formation at L-Area was 0.6 meter per day (Section F.2.6.2), the lateral ground-water velocity would be EN-44 | about 21 meters per year. Root (1983) suggests that a lateral ground-water velocity of 14.5 meters per year per percent gradient is appropriate for the

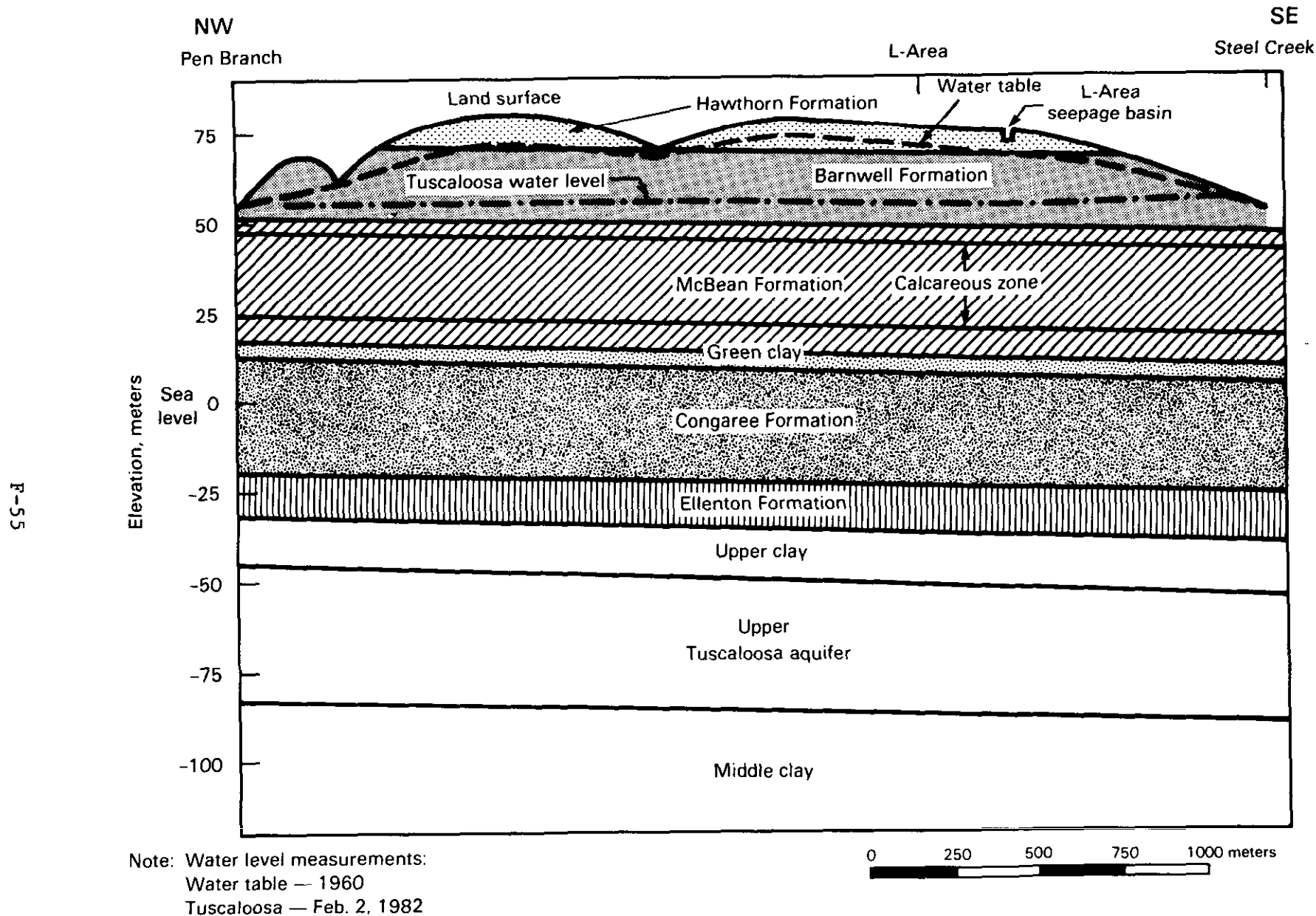
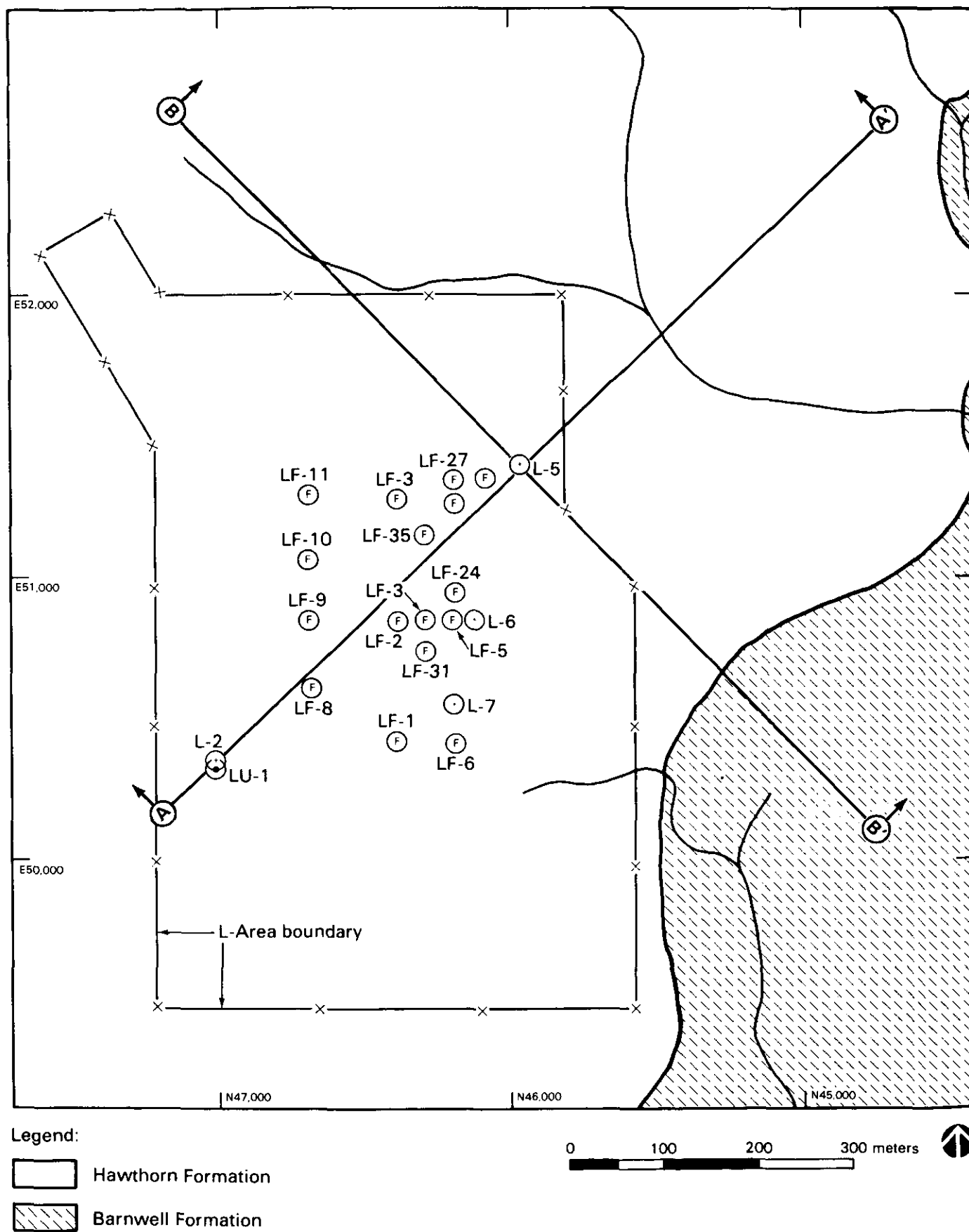


Figure F-22. Hydrogeology at L-Area.



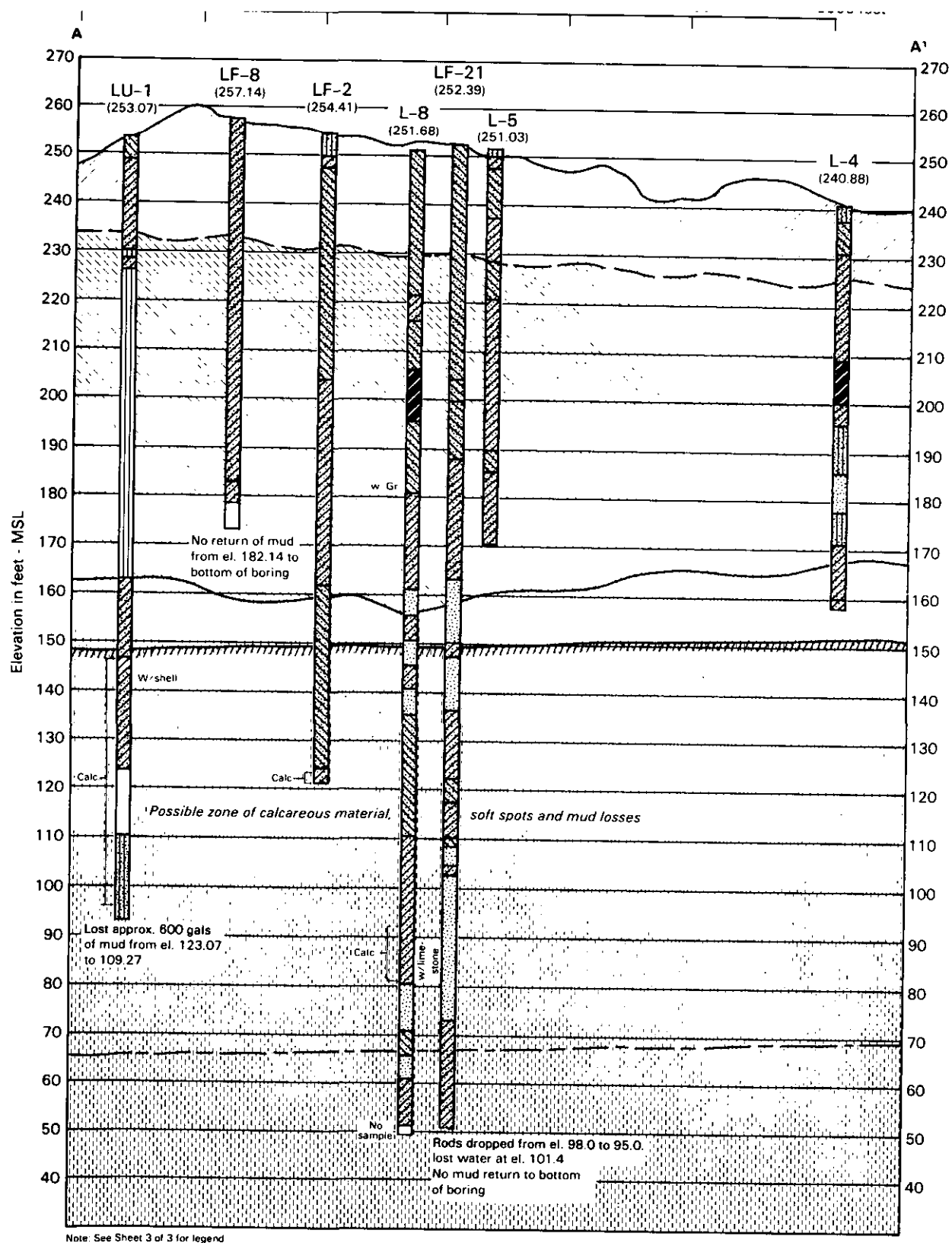


Figure F-23. Geologic sections across L-Area (Sheet 2 of 3).

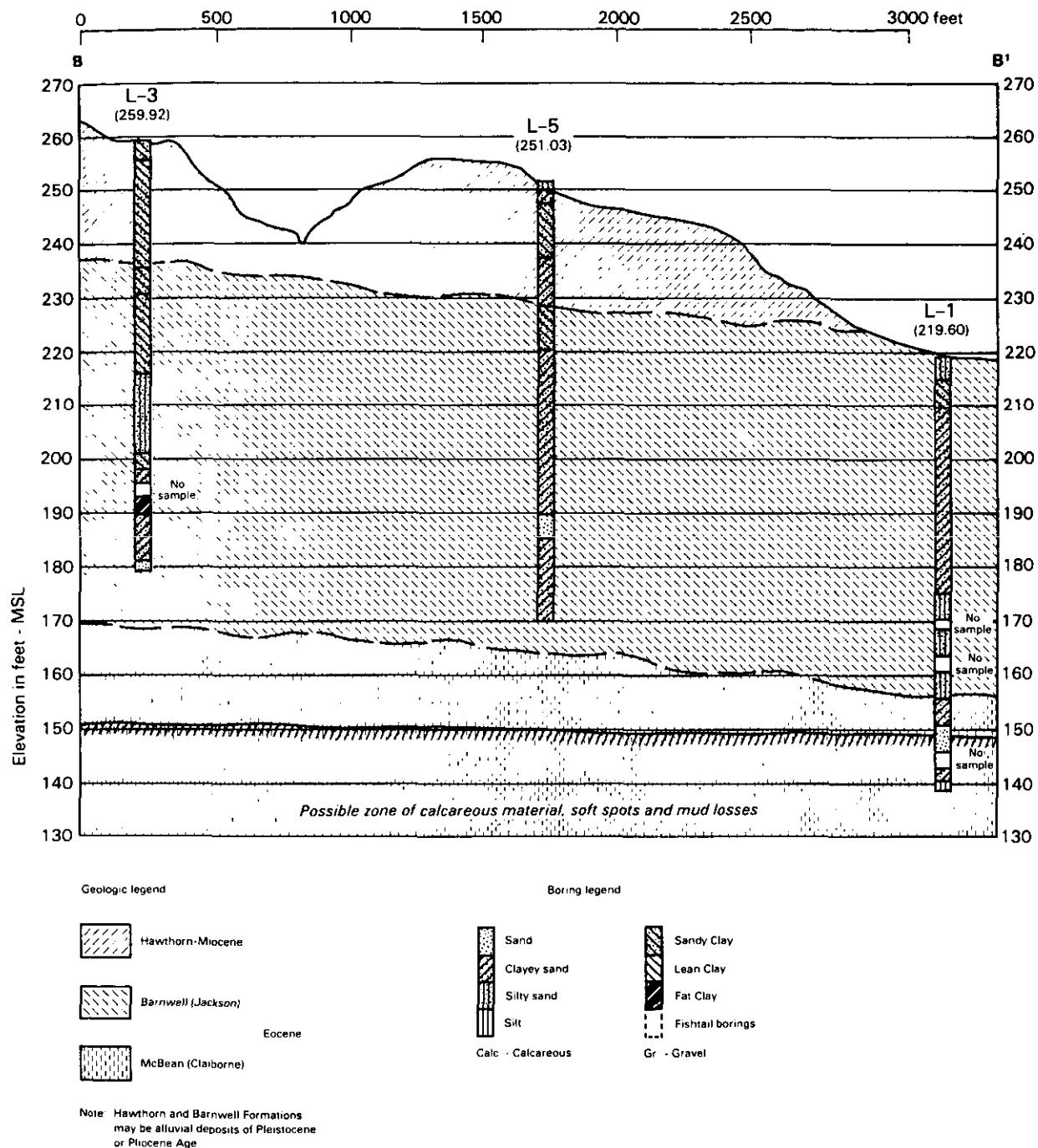
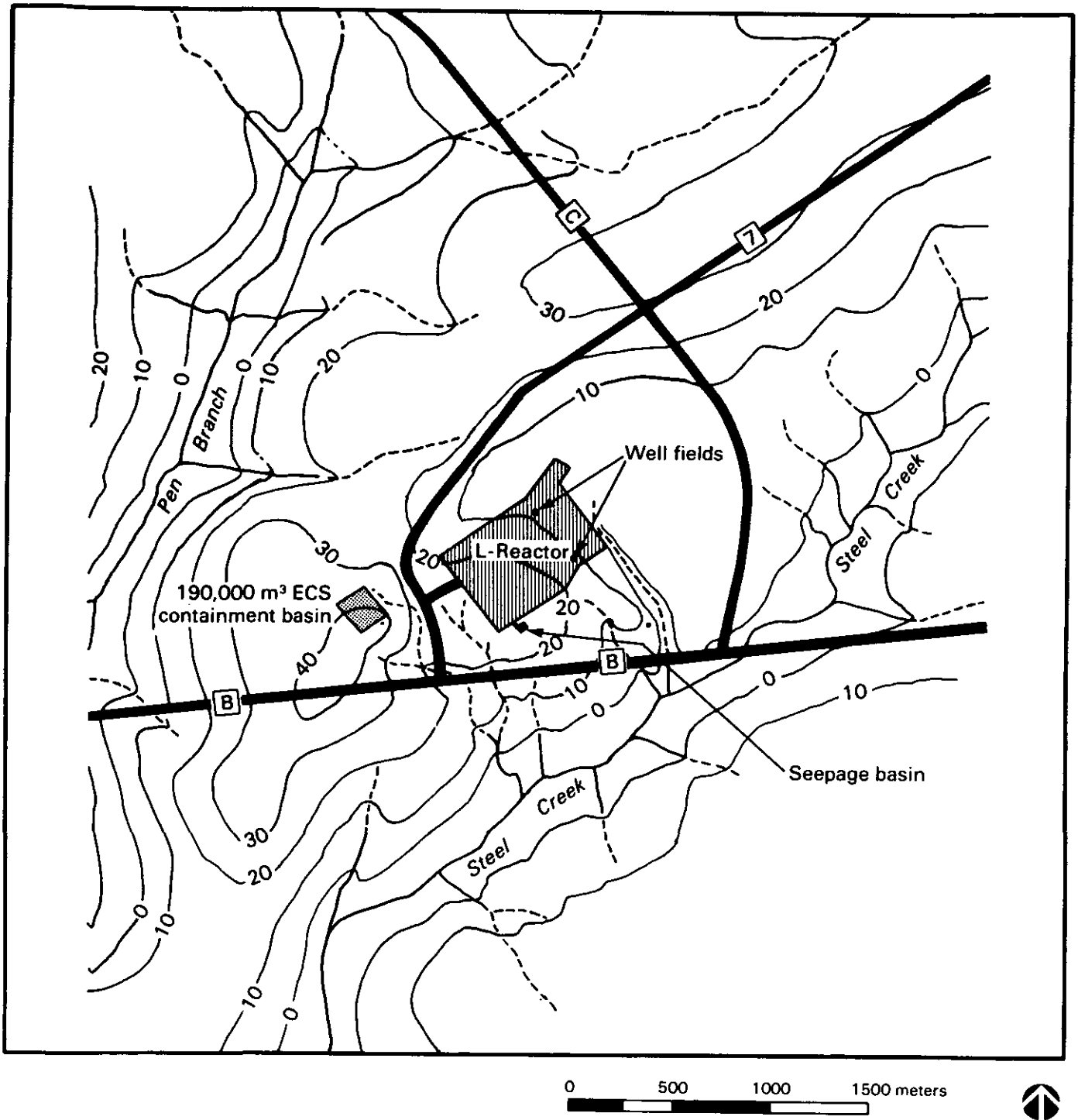


Figure F-23. Geologic sections across L-Area (Sheet 3 of 3).



Note: Contours shown in feet; 1.0 feet = 0.3048 meter.

Source: Langley and Marter (1973).

Figure F-24. Depth to the water table in the vicinity of L-Area (1965).

TC

Barnwell Formation. This relationship yields a lateral velocity of about 27 meters per year between the L-Reactor seepage basin and Steel Creek. Because the L-Reactor seepage basin will not receive continuous discharges of low pH wastewater that enhance seepage (as in F- and H-Areas), a travel time of at least 18 years is expected for the 600-meter path between the basin and the creek.

Water levels have not been measured in the McBean or Congaree Formations at L-Area, but Figure F-18 indicates that the water level in the Congaree Formation should be about 50 meters above sea level. The water elevation in the Tuscaloosa Formation (Well 29-L) was 57 meters in 1951 before pumpage began. In 1982 the static Tuscaloosa water level was 55 meters in elevation. Thus, the heads decrease with depth to the Congaree Formation and then increase with depth in the Ellenton and Tuscaloosa Formations.

F.3 GROUND-WATER DEVELOPMENT

F.3.1 Use of ground water

Ground-water users within a 32-kilometers radius of the center of SRP were surveyed. Information was obtained from the South Carolina Department of Health and Environmental Control (SCDHEC), the South Carolina Water Resources Commission (South Carolina Water Resources Commission, 1971; Dukes, 1977), from files at the Savannah River Plant, and from Siple (1967).

Most municipal and industrial water supplies in Aiken County are developed from the Tuscaloosa Formation, which occurs at shallower depths as the Fall Line is approached. Domestic water supplies are primarily developed from the Barnwell, McBean, and Congaree Formations. In Barnwell and Allendale Counties, the Tuscaloosa Formation occurs at increasingly greater depths; some municipal users are therefore supplied from the shallower Congaree and McBean Formations or from their limestone equivalent. In these counties, domestic supplies are developed from the Barnwell and the McBean Formations.

TC | The survey identified 44 municipalities and industries that use more than 18.9 cubic meters per day from ground-water sources. The total pumpage for these users is about 106,300 cubic meters per day. The locations of these users are shown in Figures F-25 and F-26, together with ground-water flow paths for the Tuscaloosa and Congaree Formations, respectively. Pertinent data are listed in Tables F-8 and F-9.

F.3.1.1 Municipal use

TC | Twenty municipal users, with a combined withdrawal rate of about 39,000 cubic meters per day, were identified (Table F-8). Talatha community (in Aiken County), the municipal user nearest to the center of the Savannah River Plant (about 11 kilometers away), uses about 150 cubic meters per day. The largest

Table F-8. Ground-water pumpage for municipal supplies^a

Map location ^b	User	Distance from center of SRP (km)	Population served	Average daily use m ³ /day	Water-bearing formation	Type of source
AIKEN COUNTY, SOUTH CAROLINA						
1	City of Aiken	34	28,000	7,570	Tuscaloosa	Springs
2	Town of Jackson	16	3,152	660	Tuscaloosa	2 wells
3	Town of New Ellenton	13	4,000	1,135	Tuscaloosa	2 wells
4	Town of Langley	31	1,330	490	Tuscaloosa	2 wells
5	College Acres	21	1,264	245	Tuscaloosa	3 wells
6	Bath Water District	31	1,239	1,230	Tuscaloosa	2 wells
7	Beech Island	27	4,500	1,135	Tuscaloosa	3 wells
8	Talatha	11	1,200	150	Tuscaloosa	2 wells
9	Breezy Hill	32	4,500	880	Tuscaloosa	4 wells
10	Burnettown	31	1,200	570	Tuscaloosa	2 wells
11	Montmorenci	23	4,232	1,600	Tuscaloosa	2 wells
12	Warrenville	31	788	1,135	Tuscaloosa	4 wells
13	Johnstown	31	1,560	545		
	Howlandville	31	1,232	380	Tuscaloosa	1 well
	Gloverville	31	1,440	545		
14	Belvedere	39	6,300	1,370	Tuscaloosa	5 wells

Table F-8. Ground-water pumpage for municipal supplies^a (continued)

Map location ^b	User	Distance from Center of SRP (km)	Population served	Average daily use m ³ /day	Water-bearing formation	Type of source
BARNWELL COUNTY, SOUTH CAROLINA						
15	Barnwell	26	6,500	15,140	Congaree	11 wells
16	Williston	19	3,800	2,650	McBean-Tuscaloosa	4 wells
17	Blackville	32	2,975	1,135	Tuscaloosa	3 wells
18	Hilda	35	315	35	Tuscaloosa	1 well
19	Elko	23	315	40	McBean	1 well
BURKE COUNTY, GEORGIA						
40	Girard	32	210	75	Tuscaloosa	3 wells

^aAdapted from Du Pont (1983).

^bSee Figure F-25.

Table F-9. Ground-water pumpage for industrial supplies

Map location ^a	User	Distance from center of SRP (km)	Population served	Average daily use (m ³ /day)	Water-bearing formation	Type of source
SAVANNAH RIVER PLANT						
20	A/M-Area	10	2,131	9,805 ^b	Tuscaloosa	4 wells
21	F-Area	3	800	9,275 ^c	Tuscaloosa	6 wells
22	H-Area	0	825	10,035 ^b	Tuscaloosa	5 wells
23	U-Area	6	110	490	Tuscaloosa	3 wells
24	Central Shops (CS)	11	600	820	Tuscaloosa	3 wells
25	CMX-TNX	13	50	1,630	Tuscaloosa	1 well
26	Class. Yd.	10	35	30	(d)	1 well
38	DWPF ^e	1	530	1,080	Tuscaloosa	2 wells
39	FMF ^f	1	280	290	Tuscaloosa	(d)
41	C-Area	5	(b)	1,900	Tuscaloosa	2 wells
42	K-Area	9	(b)	1,630	Tuscaloosa	2 wells
43	P-Area	9	(b)	1,900	Tuscaloosa	2 wells
44	L-Area	9	(b)	1,355 ^b	Tuscaloosa	2 wells
AIKEN COUNTY, SOUTH CAROLINA						
27	U.S. Forest Service	11	70	20	Tuscaloosa	1 well
28	Graniteville Company	32	2,156	525	Tuscaloosa	1 well
29	J. M. Huber Company	29	(b)	8,440	Tuscaloosa	1 well
30	Augusta Sand & Gravel	35	(b)	3,595	Tuscaloosa	1 well
31	Cyprus Mines Corp.	32	(b)	1,420	Tuscaloosa	1 well
32	Florida Steel Corp.	32	(b)	75	Tuscaloosa	1 well
33	Valchem	29	(b)	410	Tuscaloosa	1 well
ALLENDALE COUNTY, SOUTH CAROLINA						
34	Sandoz Co.	29	(b)	10,900	Tuscaloosa	1 well

TC

Table F-9. Ground-water pumpage for industrial supplies (continued)

Map location ^a	User	Distance from center of SRP (km)	Population served	Average daily use (m ³ /day)	Water-bearing formation	Type of source
BARNWELL COUNTY, SOUTH CAROLINA						
35	E. T. Barwick Ind.	26	400	945	Tuscaloosa	2 wells
FUTURE INDUSTRIAL SUPPLIES						
36	Barnwell NFP ^g	18	450	1,100	Tuscaloosa Congaree	1 well
37	A. W. Vogtle NPS ^h	24	(b)	950	Tuscaloosa Congaree	2 wells 3 wells

^aSee Figure F-25; adapted from Du Pont (1983).

^bUsage is not expected to increase when L-Reactor operation is resumed.

^cIn September 1984, usage is expected to decrease to 4905 cubic meters per day when the F-Area powerhouse is placed in standby status; usage is then expected to increase to 6540 cubic meters per day as the result of L-Reactor operation.

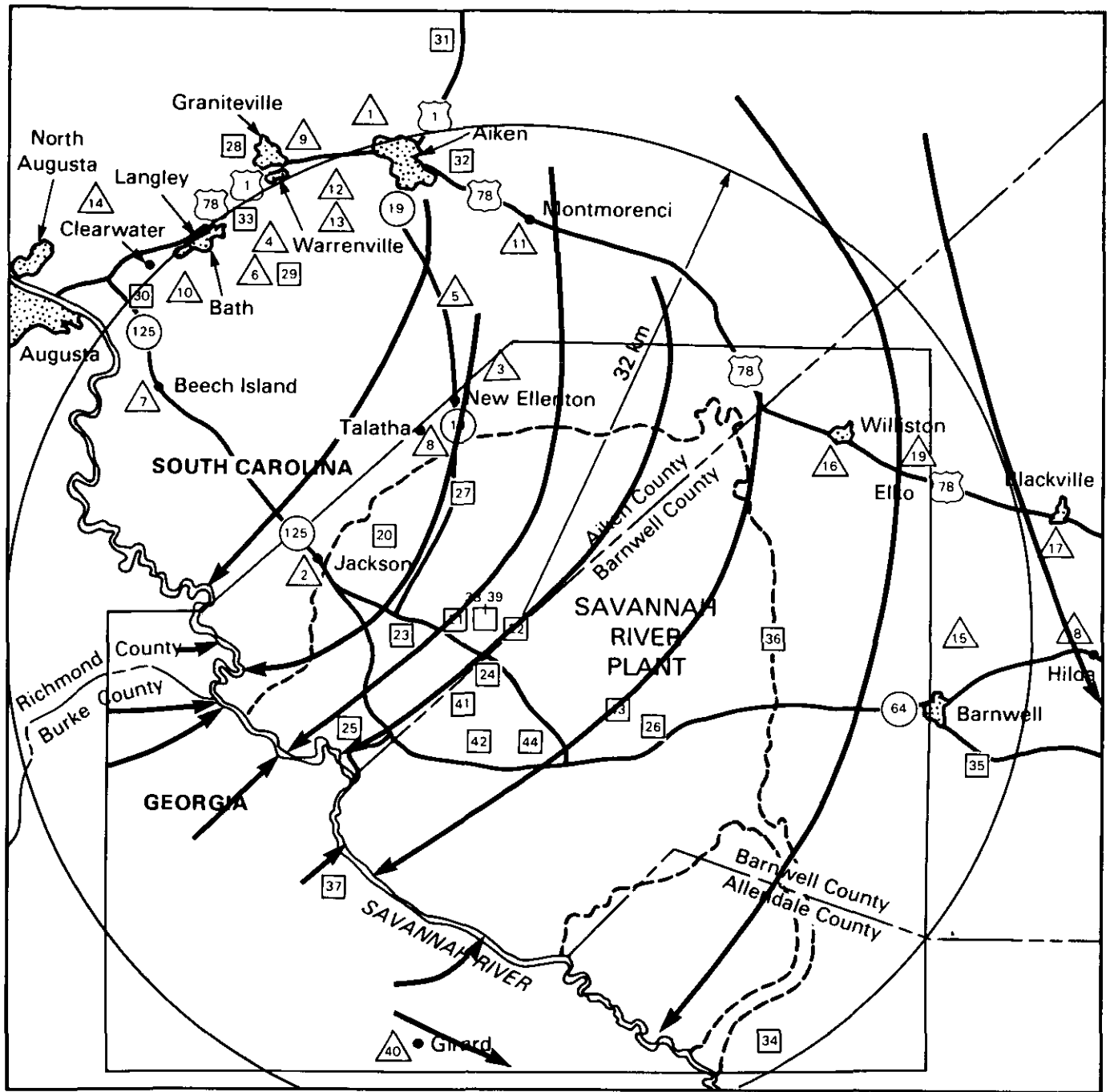
^dData not available.

^eThe Defense Waste Processing Facility (DWPF) is under construction; the exact number of water wells and pumping requirements are not firmly established. Current plans (December 1983) indicate a usage of less than 1080 cubic meters per day supplied by one or two wells, each with a capacity of 5450 cubic meters per day.

^fThe Naval Fuel Materials Facility (FMF) is under construction; the pumping requirements are not firmly established.

^gThe Barnwell Nuclear Fuel Plant has not processed and is not expected to process nuclear fuel.

^hThe Vogtle Nuclear Power Station is under construction; its total ground-water requirements are not available.



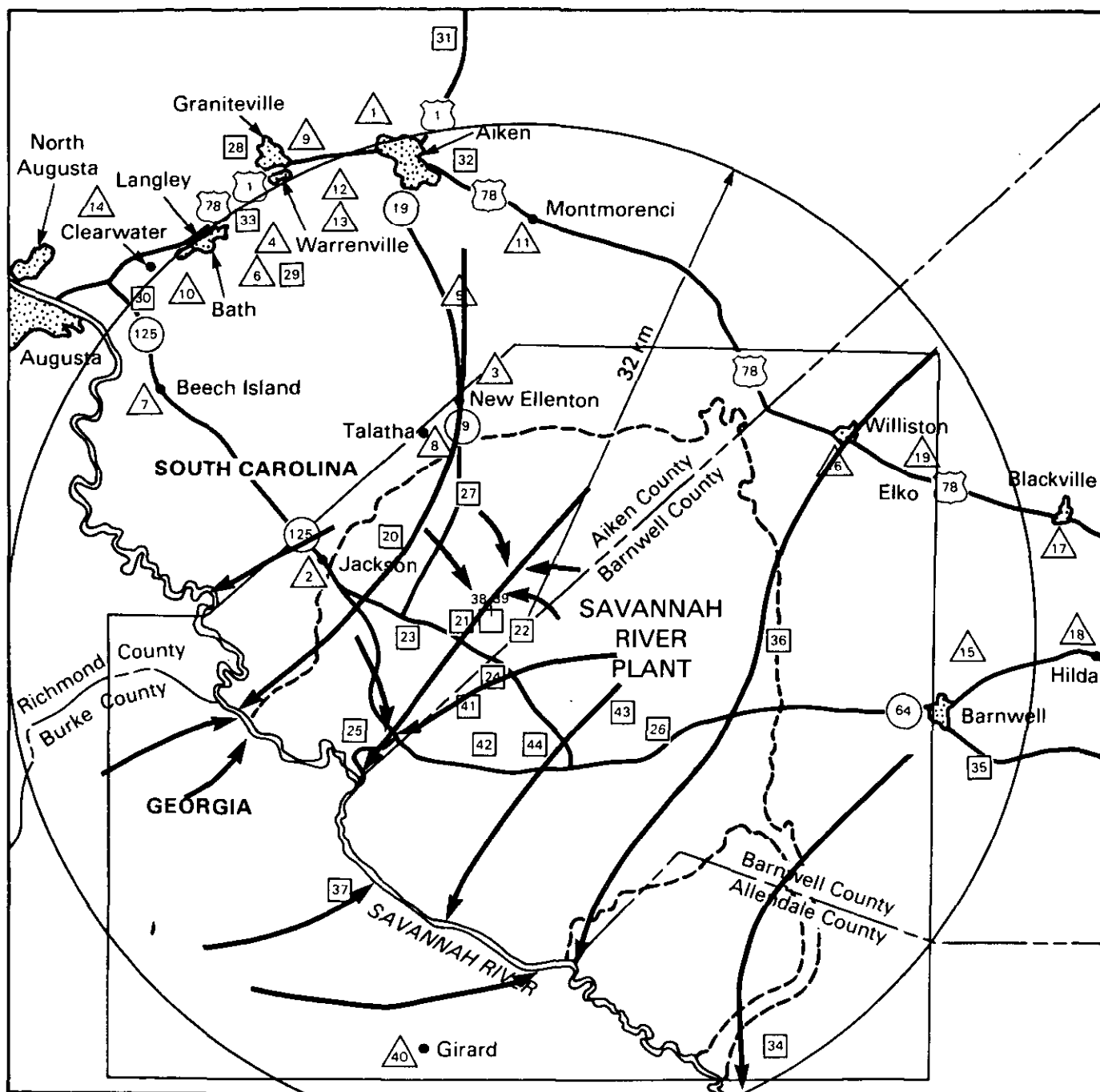
Legend:

-  Municipal user
-  Industrial user
-  Marine & Routh's 1974 study area
-  Direction of ground-water flow in Tuscaloosa Formation

Note: Users are identified in Tables F-8 and F-9; flow directions are developed from Figures F-8 and F-9.

Source: Du Pont (1983)

Figure F-25. Locations of municipal and industrial ground-water users within a 32-kilometer radius of the center of Savannah River Plant, showing the direction of ground-water flow in the Tuscaloosa Formation.



Legend:



Municipal user



Industrial user



Marine & Routh's 1974 study area



Direction of ground-water flow in Congaree Formation

Note: Users are identified in Tables F-8 and F-9; flow directions are developed from Figure F-18 and Figure 3-21 in Du Pont, 1983.

Source: Du Pont (1983)

Figure F-26. Locations of municipal and industrial ground-water users within a 32-kilometer radius of the center of Savannah River Plant, showing the direction of ground-water flow in the Congaree Formation.

municipal user is the town of Barnwell (in Barnwell County), about 26 kilometers away; it uses 15,140 cubic meters per day, some of which is supplied to local industry.

Total municipal pumpage from the Tuscaloosa Formation is about 23,500 cubic meters per day. Total municipal pumpage is 38 cubic meters per day from the McBean Formation and 15,000 cubic meters per day from the Congaree Formation. | TC

F.3.1.2 Industrial use

Twenty-four industrial users were identified as shown in Table F-9, including 13 SRP users. Total industrial pumpage from the Tuscaloosa Formation, including the Savannah River Plant, is about 67,300 cubic meters per day. | TC

The Barnwell Nuclear Fuel Plant has not, nor is it currently expected to operate and the only pumpage (for domestic purposes, boiler make-up, and wash water) is estimated to be about 0.76 cubic meter per minute from one Tuscaloosa well and one Congaree well. The Sandoz Plant, about 29 kilometers south of the center of Savannah River Plant, is the largest offsite industrial user and pumps about 10,900 cubic meters per day from one Tuscaloosa well. This pumpage began about 1978.

Construction work at the Vogtle Nuclear Power Plant, across the Savannah River from Savannah River Plant restarted in 1977. Water is supplied from two Tuscaloosa wells about 260 meters deep and three shallower wells about 73 meters deep, probably in the Congaree Formation. The average pumping rate for the total five-well system was 950 cubic meters per day in 1982. This pumpage also began about 1978.

F.3.1.3 Agricultural use

In 1980 irrigation from ground-water sources in Allendale County amounted to an average annual pumping rate of 15,000 cubic meters per day. In Barnwell County this amounted to 4100 cubic meters per day. Most of the growth of irrigation systems in these two counties has taken place over the last several years. Some of these irrigation systems are in the Tuscaloosa, but some are in the limestone equivalent of the McBean or Congaree Formations.

F.3.1.4 Domestic use

In addition to the large municipal and industrial users, 25 small communities and mobile home parks, 4 schools, and 11 small commercial interests are listed in the files of the South Carolina Department of Health and Environmental Control as using ground water. Wells serving these users are generally equipped with pumps of 54 to 325 cubic meters per day capacity and do not draw large

TC | quantities of water. Most produce from shallow aquifers. The estimated total withdrawal from these 40 users is about 1000 cubic meters per day. However, incomplete State records provide little information on screened zone, formation, or actual usage. Two South Carolina State Parks are within the survey area: (1) Aiken State Park, with seven wells, and (2) Barnwell State Park, with two wells. The Edisto Experimental Station at Blackville pumps an average of 70 cubic meters per day from the Congaree Formation. Several shallow wells produce small quantities (pump capacity of less than 40 liters per minute) of water for guardhouses at the Savannah River Plant.

TC | There are a large number of shallow drilled and dug wells in the survey area outside of Savannah River Plant. Pumpage from these wells is not included in this survey.

F.3.2 SRP ground-water usage

TC | Table F-10 shows the pumping rates from 1968 to 1983 for individual areas at SRP. The location of most of these areas is shown in Figure F-25. The centers for greatest ground-water pumpage at Savannah River Plant are in A-, F-, and H-Area. The total pumpage at Savannah River Plant is shown in graphical form in Figure F-27. In 1983 annual ground-water usage was 27.0 cubic meters per minute. Siple (1967) concluded that (1) the Tuscaloosa aquifer can supply about 37.8 cubic meters per minute for the operation of Savannah River Plant with no adverse effects on pumping capabilities in existing 1960 wells; and (2) potentially, the aquifer could produce more water if well fields were properly designed. In 1960 the SRP pumpage from the Tuscaloosa was about 18.9 cubic meters per minute.

F.4 HYDROLOGIC INTERRELATIONSHIPS AT SRP

F.4.1 Natural interrelationships

Although a number of hydrologic interrelationships between the various hydrogeologic units at Savannah River Plant have been discussed in Section F.2, which describes the hydrostratigraphic units, the purpose of this section is to summarize and amplify these relationships.

Precipitation at Savannah River Plant averages about 121 centimeters per year with a maximum of 187 centimeters in 1964 and a minimum of 73 centimeters in 1954 (for the period 1952 through 1982). Table F-11 shows the monthly precipitation at Savannah River Plant near the administration area since 1952. Although there may be both spatial and temporal variations in the fraction of this precipitation that recharges the ground water, the overall average annual recharge is about 30 percent of the total or 38 centimeters. This value varies with slight variations in the hydraulic conductivity of the shallow layers of sediment, the proportion of the rainfall that falls in the nongrowing season, the antecedent wet or dry conditions, and drainage patterns.

Table F-10. Ground-water pumping rates by area at Savannah River Plant, 1968 to 1983
(average continuous pumping rate in cubic meters per minute)

Area	Wells	1968-1973 (average)	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1985 ^a
A/M	4	5.1	4.3	4.3	4.2	4.4	4.0	4.1	4.4	5.1	5.03	6.81	6.81
F	6	6.3	5.3	3.9	4.5	4.6	4.5	5.0	5.2	5.3	5.87	6.44	4.54
H	5	5.9	6.1	5.8	6.5	6.3	6.7	6.8	6.9	7.4	7.19	7.19	7.19
CS	3	0.25	0.34	0.36	0.44	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.74
D	(b)	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
U	3	0.48	0.38	0.38	0.28	0.28	0.28	0.28	0.28	0.28	0.34 ^c	0.34 ^c	0.34 ^c
C	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	1.13
K	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.13	1.27
L	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.28 ^d	0.94	0.94
P	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	1.13	1.32	1.32
CMX-TNX	3	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.61	1.13	1.13	1.13
Total		18.8	16.6	14.9	16.1	16.3	16.2	16.9	17.5	20.4	23.8	27.0	25.4

^aProjected use with L-Reactor operating. In September 1984, the pumping rate in F-Area is expected to decrease to 3.41 cubic meters per minute because ground water will no longer be used by the F-Area powerhouse (to be placed in standby status). The L-Reactor increment is 1.13 cubic meters per minute.

^bWells are no longer in use.

^cIncludes temporary construction area.

^dCurrently about 0.28 cubic meter per minute; 0.94 projected in NPDES Permit SC0000175 (Du Pont, 1981) application.

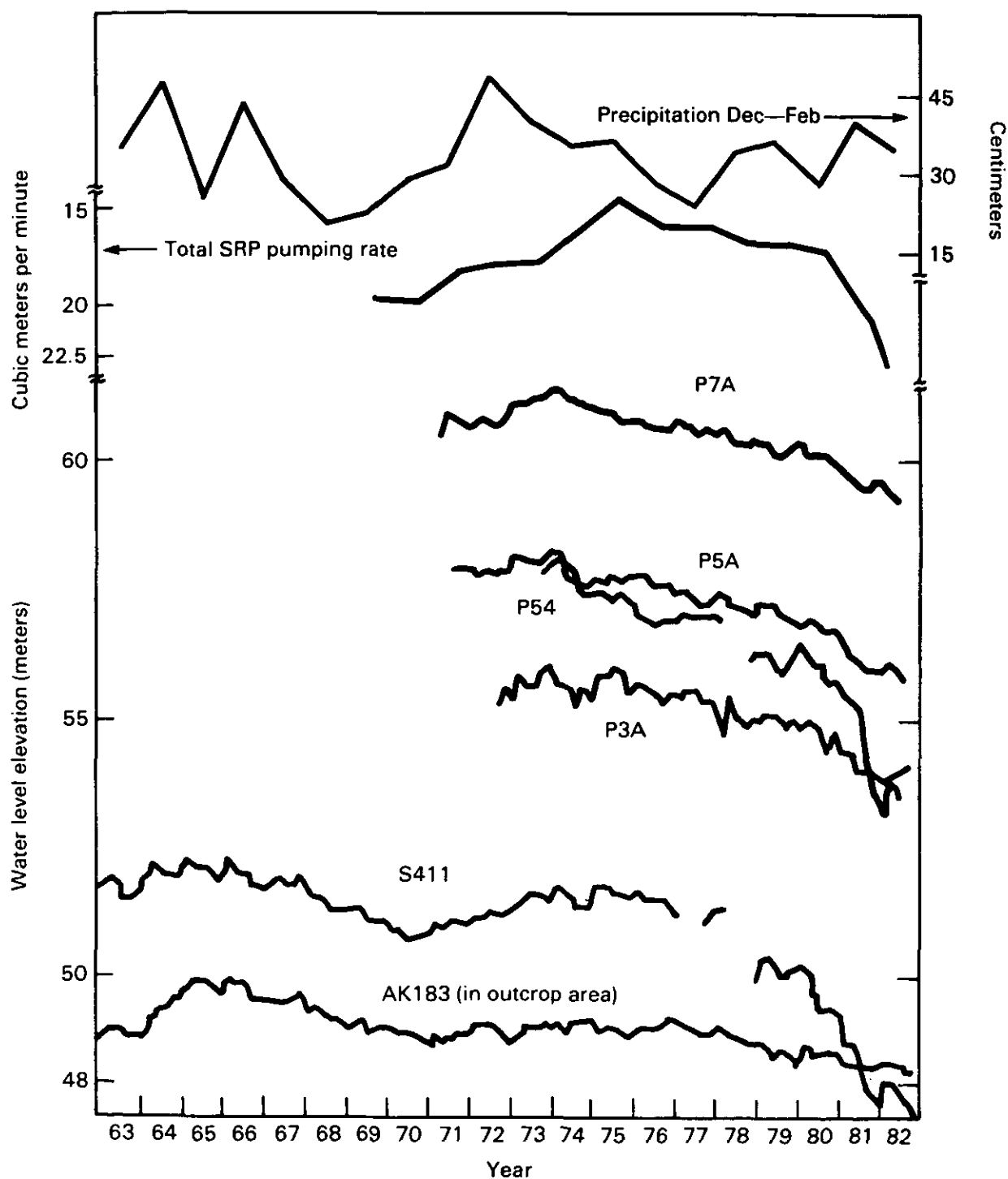
Table F-11. Savannah River Plant precipitation by month and year, 1952 through 1982
(in centimeters)^a

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Departure from average
1952	5.3	8.2	16.6	7.9	14.1	14.4	7.2	15.2	8.5	3.5	7.3	10.1	118.2	-3.1
1953	6.8	13.9	9.7	7.5	11.2	13.7	9.2	9.2	21.7	0.3	2.6	19.1	124.9	3.6
1954	3.2	4.2	7.5	6.4	7.3	7.4	5.2	10.4	3.6	3.3	7.5	7.3	73.2	-48.2
1955	12.1	6.7	5.6	14.1	11.5	8.4	10.0	12.9	8.7	3.4	7.4	1.2	101.9	-19.4
1956	4.2	20.2	12.3	8.2	7.8	5.9	11.0	8.1	11.6	4.6	2.4	5.2	101.5	-19.9
1957	5.2	4.0	10.9	7.0	20.4	10.6	8.9	6.1	12.8	15.5	16.4	5.7	123.5	2.2
1958	10.2	11.1	12.6	14.3	5.3	6.4	13.5	7.0	2.8	2.4	0.5	11.2	97.4	-24.0
1959	9.0	15.4	16.4	5.2	9.7	10.3	14.7	7.4	22.1	27.6	5.0	9.0	151.8	30.4
1960	17.6	14.8	14.6	12.9	5.0	9.3	13.4	7.1	12.3	2.5	2.1	7.4	118.9	-2.4
1961	9.1	14.6	18.4	20.8	9.9	7.6	7.8	18.2	2.5	0.2	4.6	16.8	130.6	9.2
1962	11.8	13.1	16.6	10.2	8.9	11.2	6.5	8.7	14.1	5.8	8.9	5.6	121.3	-0.1
1963	15.1	9.2	8.5	9.4	7.6	21.4	8.1	2.6	13.6	0.0	9.3	11.4	116.3	-5.1
1964	19.8	15.2	14.7	15.1	9.2	11.4	26.5	31.3	14.4	15.6	2.2	11.1	186.6	65.3
1965	5.1	16.2	22.0	6.2	3.4	12.8	20.4	4.9	7.2	6.6	5.5	3.6	113.9	-7.5
1966	18.2	15.1	11.3	6.4	14.0	11.8	10.4	13.3	9.2	3.2	2.7	8.6	124.3	3.0
1967	9.3	9.7	14.4	7.2	12.7	9.5	19.1	18.6	4.3	1.6	6.4	8.0	120.7	-0.6
1968	10.1	2.4	3.8	5.4	8.8	15.7	9.9	10.8	5.7	7.6	8.6	6.9	95.8	-25.6
1969	5.1	6.2	8.6	10.4	7.7	10.0	6.9	13.8	11.6	2.9	1.0	10.6	94.8	-26.5
1970	7.1	6.8	18.7	3.5	10.6	8.8	12.3	9.6	4.3	12.7	4.3	12.5	111.3	-10.1
1971	13.0	10.6	22.0	7.4	7.6	15.0	26.7	22.3	9.7	15.1	5.9	7.3	162.6	41.2
1972	22.6	11.2	7.2	1.4	12.0	16.7	6.7	15.4	3.7	3.0	9.0	13.3	122.3	1.0
1973	13.6	13.4	16.2	11.6	8.9	27.7	15.3	9.7	9.4	3.1	0.8	11.8	141.5	20.1
1974	6.6	17.9	7.3	7.4	10.5	7.1	10.4	15.9	8.2	0.2	5.6	9.7	106.7	-14.6
1975	12.6	16.9	15.0	11.2	13.1	9.8	21.7	9.7	13.2	4.4	8.7	5.2	141.4	20.1
1976	10.6	2.7	9.7	6.4	27.7	11.0	5.0	4.2	13.9	12.5	10.6	12.9	127.3	5.9
1977	9.4	4.1	17.4	3.2	4.5	6.3	8.7	18.5	14.0	10.8	4.1	9.8	111.0	-10.3
1978	25.5	3.4	7.8	9.0	9.2	8.7	10.5	13.0	10.3	0.2	9.0	4.8	111.2	-10.2
1979	9.1	19.7	7.8	16.5	22.7	3.9	19.9	5.4	15.6	3.4	10.0	5.5	139.6	18.2
1980	13.0	8.8	27.8	4.3	8.9	7.6	2.3	5.2	14.9	5.4	6.4	4.9	109.4	-12.0
1981	2.3	12.8	12.0	5.3	17.5	10.9	10.1	14.7	1.4	7.1	2.5	24.3	120.8	-0.6
1982	10.0	11.3	6.4	14.4	6.9	10.8	29.2	12.7	11.7	9.8	6.1	12.3	141.6	20.3

Table F-11. Savannah River Plant precipitation by month and year, 1952 through 1982
(in centimeters)^a (continued)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Departure from average
Average	10.7	11.0	12.9	8.9	10.8	11.0	12.5	11.7	10.2	6.3	5.9	9.5	121.4	
Maximum	25.5	20.2	22.8	20.8	27.7	27.7	29.2	31.3	22.1	27.6	16.4	24.3	186.6	
Year	1978	1956	1980	1961	1976	1973	1982	1964	1959	1959	1957	1981	1964	
Minimum	2.3	2.4	3.8	1.4	3.4	3.9	2.3	2.6	1.4	0.0	0.5	1.2	73.2	
Year	1981	1968	1968	1972	1965	1979	1980	1963	1981	1963	1958	1955	1954	

^aAdapted from Du Pont (1983).



Notes: Well S411 is screened in the Ellenton Formation; the remaining wells are screened in the Tuscaloosa Formation.
Figure F-9 shows well locations.

Source: Du Pont (1983).

Figure F-27. Hydrographs of Tuscaloosa and Ellenton wells.

Infiltrating water moves vertically through the unsaturated zone at a rate of about 2 meters per year in the central part of Savannah River Plant to recharge the water table which is commonly in the Barnwell Formation. This rate varies spatially and temporally. Upon reaching the water table, the recharging water travels on a path that has both vertical and horizontal components. The magnitude of these two components depends on the vertical and horizontal components of the hydraulic conductivity. Clay layers of low hydraulic conductivity tend to impede vertical flow and enhance horizontal flow. If the horizontal hydraulic conductivity is low, recharging water will tend to "pile up" above the clay, and the water table will be high, or perched. On the other hand, if the hydraulic conductivity is high, the recharging water will be conducted more quickly away from the recharge area, and the water table will be low.

Figure F-5 shows the head relationship of the various hydrostratigraphic units in the central part of Savannah River Plant (which includes F-, H-, and L-Area), and Figure F-15 shows how these relationships change as Upper Three Runs Creek is approached. The water table is high in this area because the tan clay inhibits the downward movement of water and the low horizontal hydraulic conductivity of the Barnwell Formation does not permit rapid removal of the water in a horizontal direction. The head builds in the Barnwell Formation sufficiently to drive the water through the material of low hydraulic conductivity--some going vertically through the tan clay and some moving laterally to the nearby tributary streams. Although there are temporal variations in the elevation of the water table, there is an overall equilibrium of the water table that depends on hydraulic conductivity, the geometry of the system, and its discharge points.

Water that enters the McBean Formation also moves on a path that has both vertical and horizontal components. The water recharging this formation through the tan clay is the difference between 38 centimeters per year and the amount of water that is removed from the Barnwell by lateral flow. Also, compared to the Barnwell Formation, the discharge points for the deeper McBean Formation are more distant from their respective ground-water divides.

The green clay has a lower hydraulic conductivity than the tan clay. As a result, recharge to the Congaree through this clay is less than the recharge to the McBean. Most of the recharge is from offsite areas. In addition, the Congaree has a higher hydraulic conductivity than the material above and as a result lateral flow is enhanced making the water levels in the Congaree much lower than those above (Figures F-5 and F-15). The discharge areas for the Congaree are the valleys of the Savannah River and Upper Three Runs Creek. Even though these discharge areas are more distant from the central part of Savannah River Plant than the discharge areas for the Barnwell and McBean Formations, the hydraulic conductivity is sufficiently high so that the natural discharge from the Congaree makes its water level much lower in this area than the formations above.

Tuscaloosa Formation water elevations in the central part of Savannah River Plant are above those in the Congaree (Figure F-5) showing that in this area, the Tuscaloosa is not naturally recharged from the Congaree. However, this upward head differential has been decreasing at about 0.16 meter per year over the

AW-1

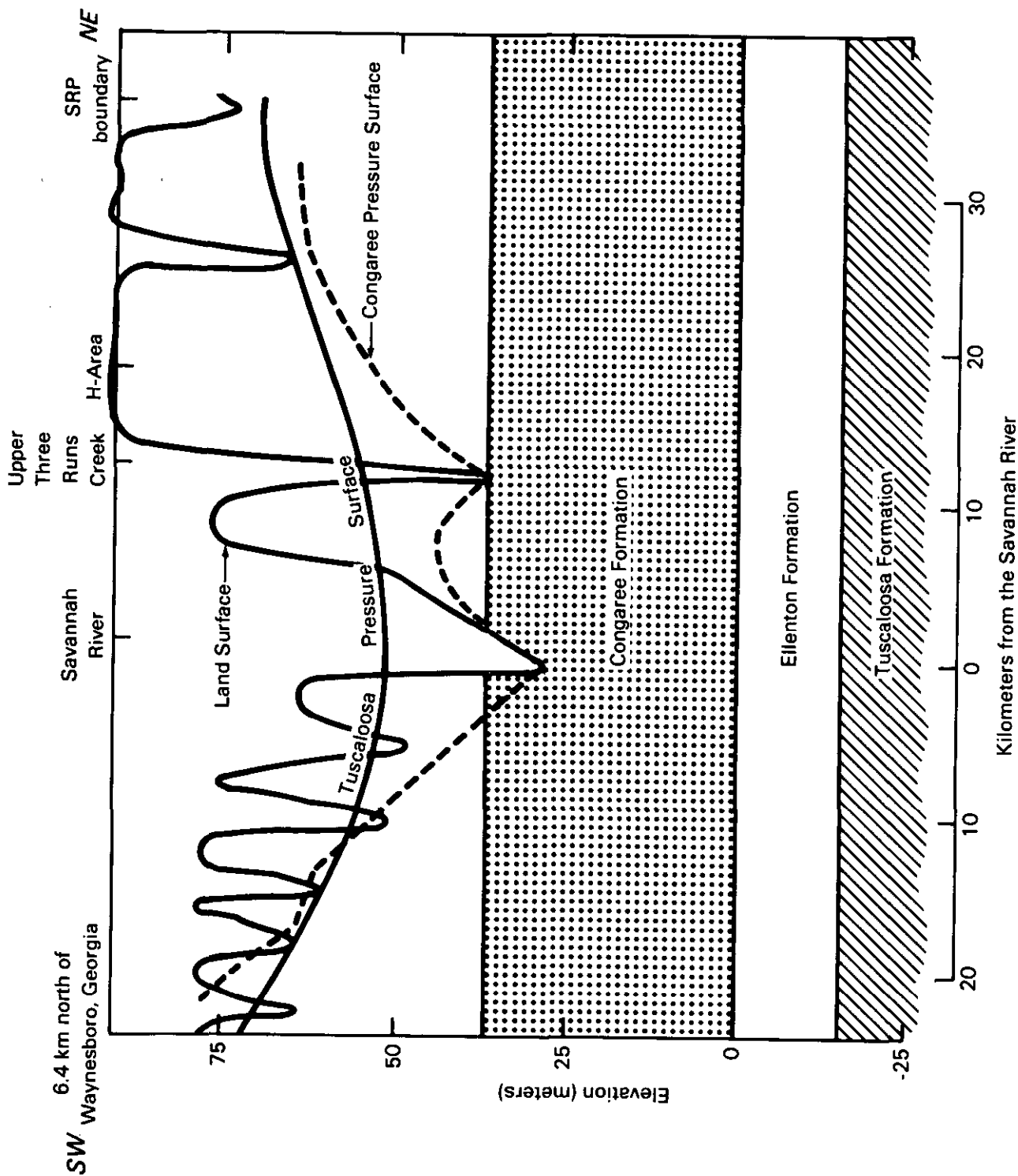
past 10 years, primarily because of increased SRP pumping (Section F.4.2). Water in the Tuscaloosa passing beneath this area is recharged through the Tertiary sediments to the north of Savannah River Plant (Figure F-7). Water is discharged from the Tuscaloosa upward into the overlying sediments in the Savannah River Valley. This relationship is shown on Figure F-28 which is a hydrologic section through H-Area approximately perpendicular to the Savannah River. This diagram shows that in the Savannah River Valley and Upper Three Runs Valley, the head in the Tuscaloosa is consistently above that of the Congaree. Water levels in the Tuscaloosa in the Savannah River Valley are commonly above land surface and wells in these areas flow naturally. This figure also shows that water from either the Tuscaloosa or the Congaree does not naturally flow from South Carolina to Georgia or vice versa. Piezometric maps prepared in 1982 confirm these facts (Georgia Power Company, 1982).

Figure F-10 shows the vertical head relationships between the Congaree, shallow Tuscaloosa, and deep Tuscaloosa in the southern part of Savannah River Plant. The head relationship between the Congaree water level and higher Tuscaloosa water elevation is the same here as in H-Area but the head difference is greater. This area is greatly influenced by the drawing down of the head in the Congaree due to the nearness of the Savannah River Valley.

The head relationships in the northwest part of Savannah River Plant (M-Area) are quite different as shown on Figure F-11. In this updip area, the green clay is discontinuous and is thinner than it is farther downdip. The tan clay has disappeared entirely. Thus, there is little impedance to downward vertical flow within the Tertiary sediments and the water levels are deeper below land surface. The sands of the Congaree Formation are not as well sorted and the hydraulic conductivity in the Congaree near M-Area is lower than that in the central part of Savannah River Plant. As a result, the lateral flow of water in the Congaree is insufficient to draw its water elevation down below that of the Tuscaloosa, thereby creating a downward head differential from the Congaree to the Tuscaloosa. Closer to the Savannah River, the discharge from the Congaree draws its water level down below that of the Tuscaloosa (Figure F-29).

The Congaree and Tuscaloosa Formations are separated in M-Area even though this area is near the updip termination of the Ellenton Formation. In places, the Ellenton consists of 18 meters of sandy clay of low hydraulic conductivity, but it appears not to be this thick continuously. Thus there may be discontinuous recharge from the Congaree to the Tuscaloosa through the Ellenton in this area.

An indication of the location of areas where there is a head reversal between the Congaree and the Tuscaloosa (higher head in the Tuscaloosa), and areas where there is not, may be obtained by constructing a map showing the difference between the Tuscaloosa piezometric map (Figure F-9) and the Congaree piezometric map (Figure F-18). This head difference map (Figure F-30) shows that the head in the Tuscaloosa is higher than the head in the Congaree in a broad area within about 10 kilometers of the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher in an area around M-Area, as discussed previously, and in the vicinity of Par Pond. It must be emphasized that this map is constructed by subtracting two piezometric maps for which data are somewhat sparse. Thus it should not be used to predict detailed head relationships but only to indicate general areas of expected relationships.



Source: Du Pont (1983); Tuscaloosa water levels from Siple (1967); Congaree water levels from Faye and Powell (1982).

Figure F-28. Hydrogeologic section perpendicular to the Savannah River through H-Area.

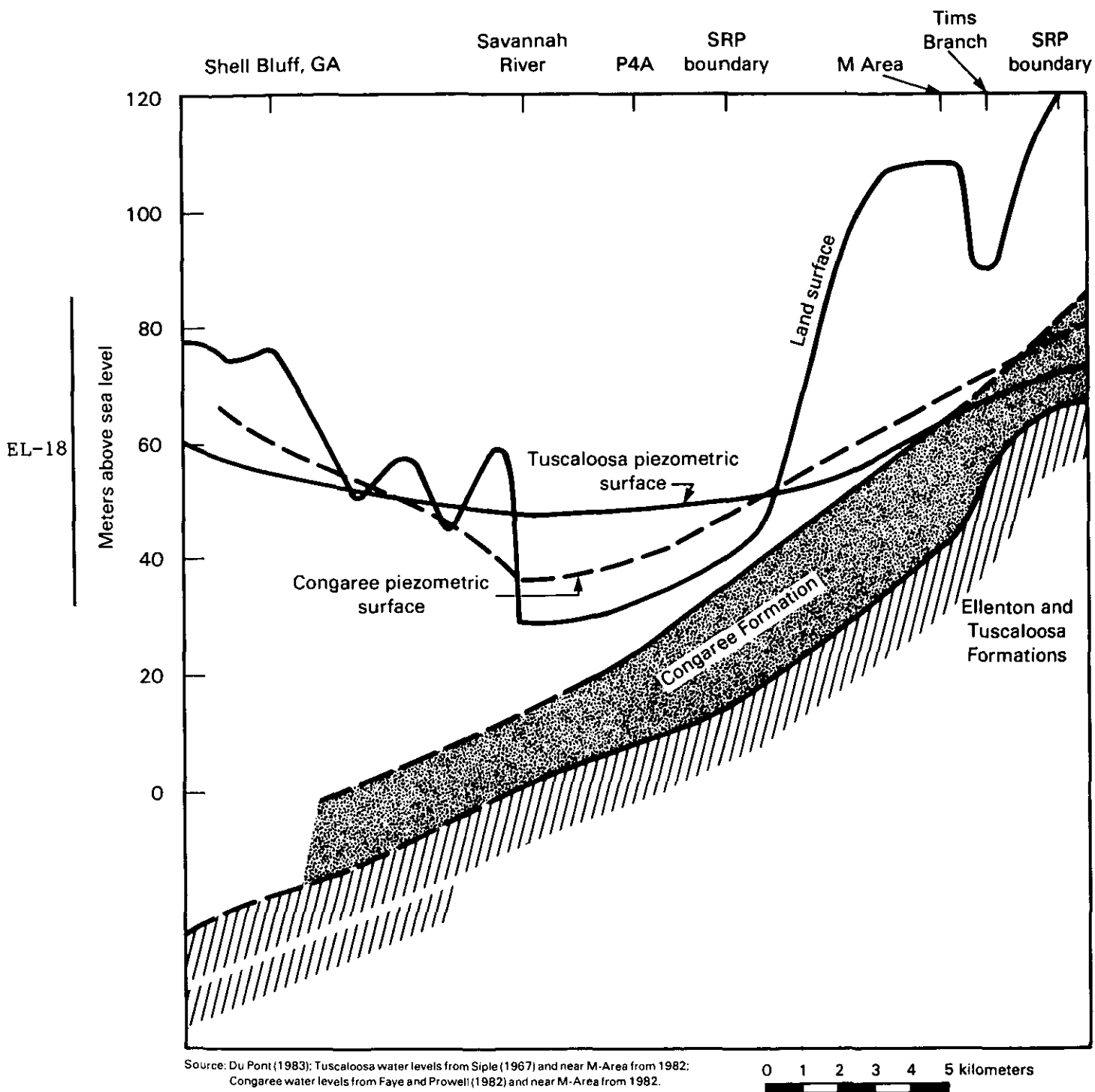


Figure F-29. Hydrologic section perpendicular to the Savannah River through M-Area.

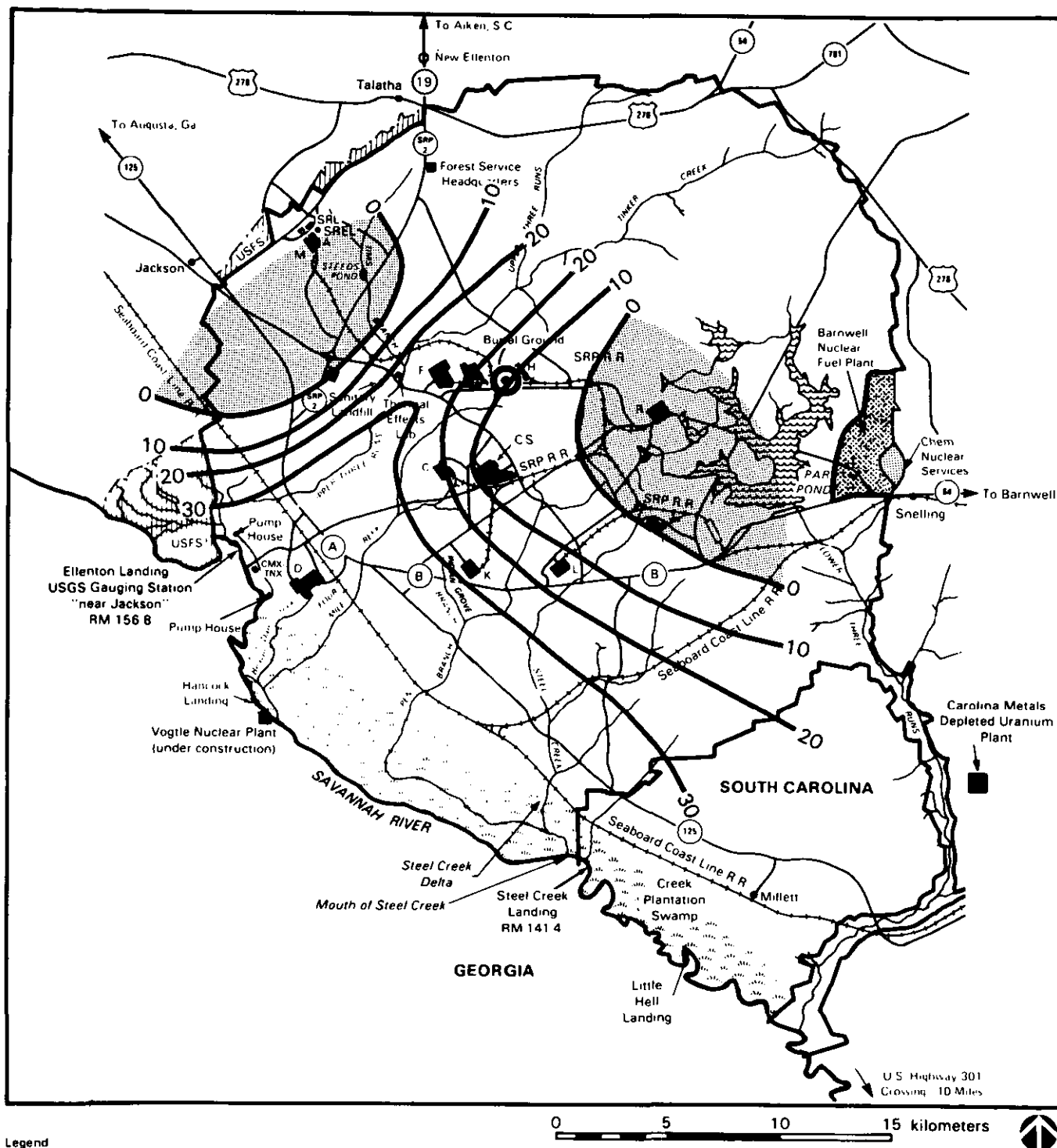


Figure F-30. Head difference between upper Tuscaloosa and Congaree Formations at SRP (May 11, 1982).

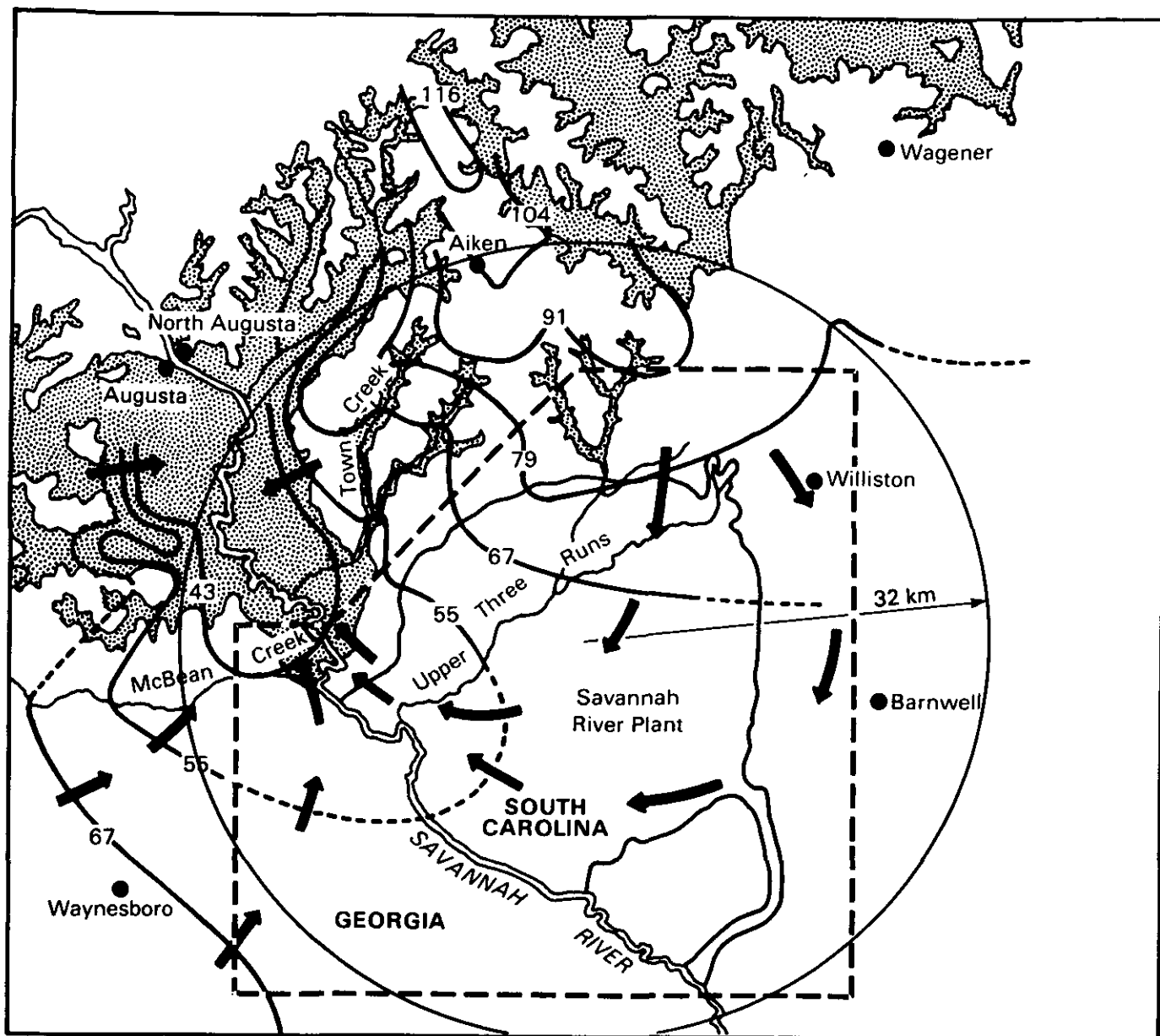
F.4.2 Relationship of ground-water use to water levels

TC In 1974 Marine and Routt (1975) made a numerical model study of the Tuscaloosa Formation in the vicinity of Savannah River Plant to assess the impact of additional planned water withdrawals from the Tuscaloosa Formation on water elevations at the Plant. The model focused on the water flux through the Tuscaloosa beneath the Plant and excluded water in the outcrop area that is recharged and discharged to the Tuscaloosa in very short distances (Figure F-31). Marine and Routt calculated a flux of 110 cubic meters per minute as being representative of conditions in the Tuscaloosa Aquifer beneath the Savannah River Plant and vicinity. However, for this EIS, a flux of 51 cubic meters per minute is conservatively chosen (the lower bound estimate of Marine and Routt). This conservative flux better reflects the fact that Tuscaloosa heads have declined since the study was performed in 1974.

TC For this EIS, drawdowns of water levels in the Tuscaloosa Aquifer were calculated using the procedure for a leaky artesian aquifer (Siple, 1967). The recommended drawdown-versus-distance curve was used in this analysis. Chapters 4 and 5 describe the onsite and offsite effects in the study area shown in Figure F-32.

TC Figure F-27 shows the hydrographs of five Tuscaloosa wells. The location of these wells except for AK-183 is shown in Figure F-9. Well AK-183 is located 29 kilometers northwest of the center of Savannah River Plant in the Tuscaloosa outcrop area and should be uninfluenced by pumpage in the vicinity of Savannah River Plant. The winter (December to February) precipitation is plotted at the top of Figure F-27 because ordinarily, it is the precipitation in this period, which is not intercepted by growing plants, that recharges the ground water. However, abundant precipitation of about twice the annual mean caused recharge during the summer of 1964. Thus, as a result, record high-water levels occurred in 1965 and 1966. A low in winter precipitation occurred in 1968, and this resulted in low-water levels in 1970. Generally high Tuscaloosa water levels occurred in 1974, but from that point on, to the present, Tuscaloosa water levels have declined. From 1972 to 1981 there has been a general decline in the winter precipitation that may partially account for the declining water levels. However, since 1975, SRP pumping has increased by about 80 percent, from 14.9 to 27.0 cubic meters per minute in 1983. Calculations show that the decline in water levels exhibited at monitoring wells P7A, P54, and P3A is related primarily to increased ground-water withdrawal at SRP. The drawdowns at these monitoring wells reflect adjustments in equilibrium levels rather than aquifer depletion. Near-equilibrium water levels are expected to occur quickly (within about 100 days) in response to changes in pumping rates (Mayer et al., 1973).

TC The current total pumpage from the Tuscaloosa Formation within 32 kilometers of the Savannah River Plant is estimated to be 63 cubic meters per minute in 1983, including pumpage from wells outside the area used by Marine and Routt (1975) to estimate the flux in the Tuscaloosa Formation (see Figures F-25 and F-31). This total should not be sufficient to exceed the ground-water flux through the area as determined by the computer model. However, the incremental pumpage might be sufficient to affect local water levels as new equilibrium piezometric surfaces are attained. Siple (1967) suggested that pumpage from the Tuscaloosa at Savannah River Plant could exceed 37.8 cubic meters per minute if wells were drilled and spaced to minimize interference between wells. Current (1983) usage at SRP is about 27.0 cubic meters per minute.

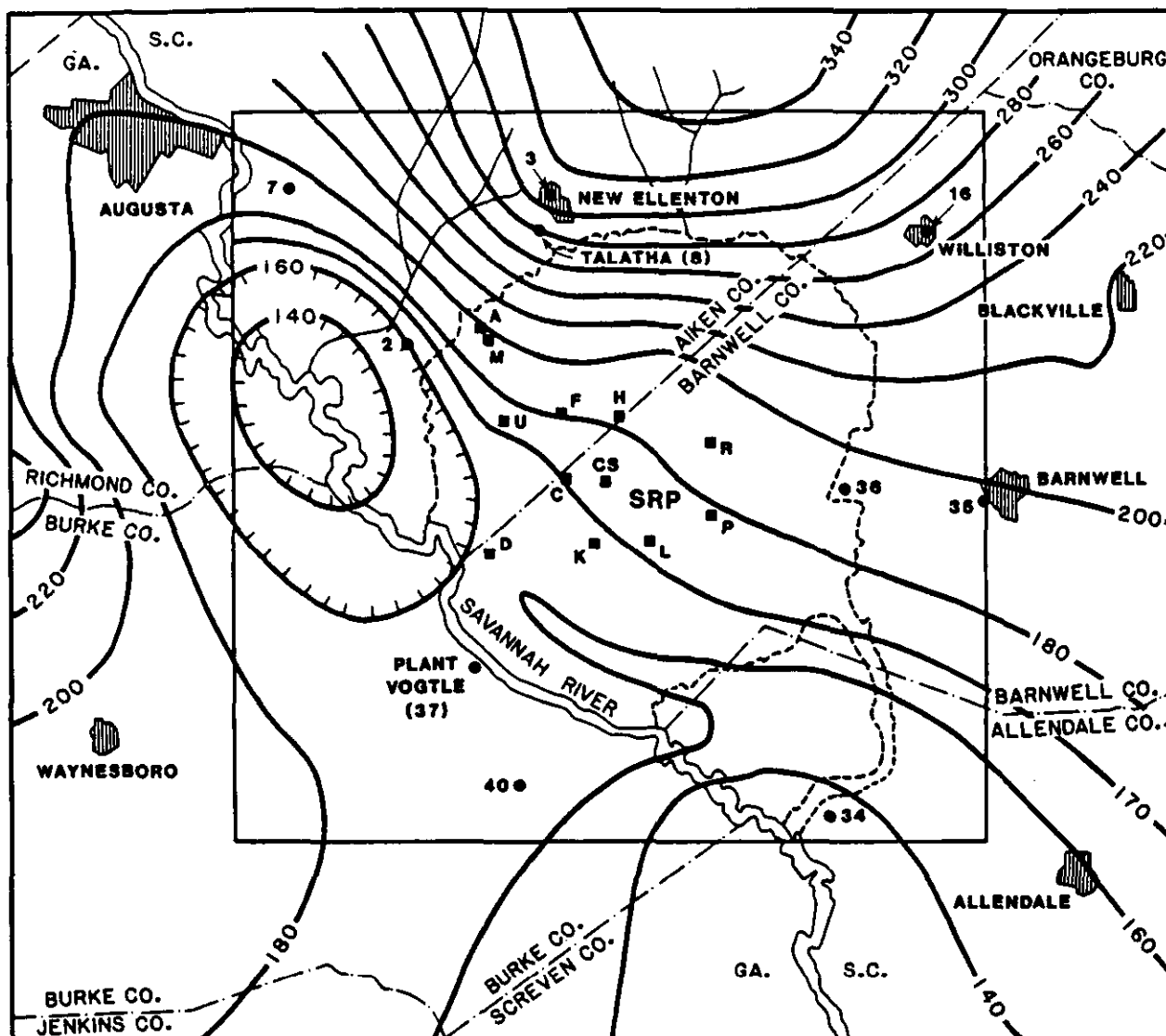


Legend:

-  Tuscaloosa Outcrop
-  Direction of ground-water flow in Tuscaloosa Formation
-  Boundary of hydrologic model
-  — 91 ---Head in Tuscaloosa meters above mean sea level

Sources: Siple (1967); Marine and Routt (1975)

Figure F-31. Boundary of numerical model of ground-water flux in the Tuscaloosa Formation beneath Savannah River Plant.



Notes:

Offsite ground-water users include (see Tables F-8 and F-9): Jackson (2), New Ellenton (3), Beech Island (7), Talatha (8), Sandoz Co. (34), Barwick Ind. (35), Barnwell NFP (36), Vogtle NPS (37), and Girard (40). 1982 onsite ground-water pumping listed in Table F-10.

Piezometric map adapted from Georgia Power Company (1982); water levels measured in feet during May-June 1982; 1.0 foot = 0.3048 meter.

Figure F-32. Study area for calculations of drawdown within Tuscaloosa Aquifer from withdrawal at end near SRP.

The decline of water levels in the Tuscaloosa Formation since the mid-1970s has reduced but not eliminated the head reversal at the Congaree Formation that occurs southeast of Upper Three Runs. The map of the head difference between the Tuscaloosa and Congaree Formations at Savannah River Plant (Figure F-30) shows that in 1982 the head reversal was still a general situation in the Savannah and Upper Three Runs Creek valleys.

To illustrate the present vertical head relationship in the central part of Savannah River Plant, Figure F-33 repeats Figure F-5, which shows water levels in 1972, but with the addition of water levels measured November 7, 1982. Heads in the Barnwell, McBean, and Congaree are from 1 to 1.5 meters below the level of 1972, but the Tuscaloosa water levels are 3 to 3.5 meters lower. Even though the head reversal at the Congaree is still present, it is reduced. Farther southeast, the current head reversal is about 7.9 meters as shown in Figure F-10 (compare Well VSC 2 to Well VSC 3).

F.4.3 Water-level depression around water supply wells

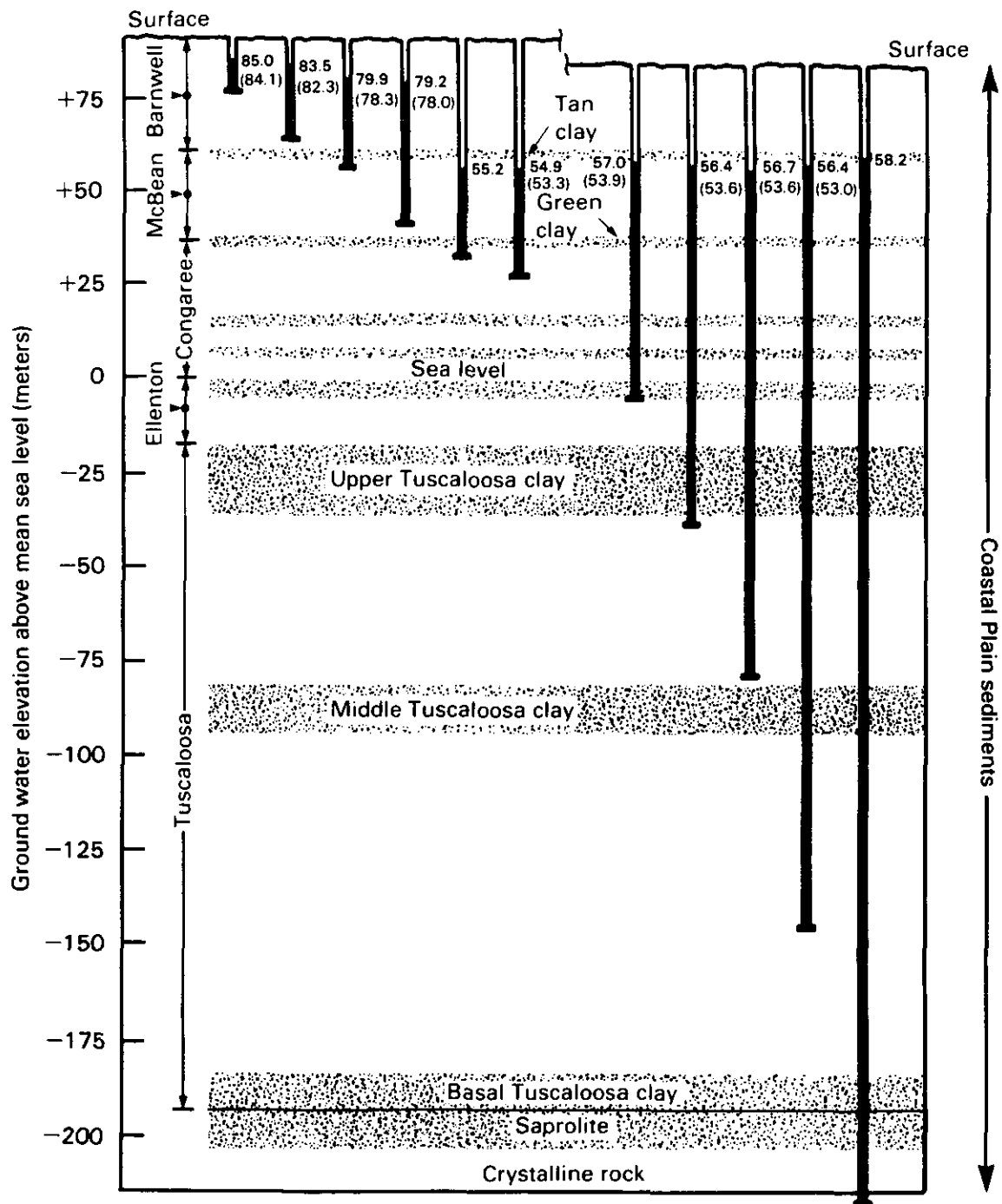
To pump water from an aquifer, the water level in the vicinity of the well must be depressed. The amount of head depression to obtain a given pumping rate is dependent on the transmissivity of the aquifer. The transmissivity of the Tuscaloosa is very high as shown in Table F-3. Thus the cones of depression at the pumping centers for the Tuscaloosa are not very deep. Drawdowns at most 5000 cubic-meter-per-day wells in the Tuscaloosa are between 6 and 12 meters. Although specific measurement of the radii of the cones of depression have not been made at every pumping center, that these cones are not extensive is shown by the facts that when Well 20A, near M-Area (see Figure F-37), was pumped at 4900 cubic meters per day only 0.3 meter of drawdown was recorded 490 meters away and that a 5000 cubic-meters-per-day well in H-Area made a drawdown change of about 0.3 meter 700 meters away during short-term tests.

During a 60-day pumping test performed at the Barnwell Nuclear Fuel Plant (Mayer et al., 1973), water was withdrawn from the Tuscaloosa Aquifer at a rate of 10,900 cubic meters per day. A drawdown of about 0.15 meter was observed at SRP monitoring well P54 (see Figure F-9), about 9 kilometers from the pumping well.

TC

Even though these cones of water level depression are not areally extensive, drawdowns of 6 to 12 meters are adequate to negate the head reversal between the Congaree and Tuscaloosa Formation where it exists. In areas where the head reversal does not exist, such as M-Area, the drawdowns increase the natural downward gradient in the area immediately surrounding the pumping wells. Because the cones of depression are not areally extensive, they probably have little hydrologic influence over waste facilities that are even moderate distances (kilometers) from the center of pumpage such as seepage basins and waste pits.

TC



Legend:

 85 Water elevation (head) in meters. Values are those existing in 1972 with 1982 measurements given in parentheses.

Note: Figure F-6 shows well locations.

Sources: ERDA (1977), Du Pont (1983).

Figure F-33. Hydrostatic head in ground water near H-Area comparing water levels in 1972 to those in 1982.

F.4.4 Effects of L-Reactor operation

As shown on Table F-10 in 1982 the pumpage at L-Area averaged only about 0.28 cubic meter per minute. When L-Area is operating, the pumping rate will be about 0.94 cubic meter per minute, slightly less than at the other operating reactors because there is no powerhouse located in L-Area. On two tests of pumping 2.8 cubic meters per minute one well (104L) had a drawdown of 8.2 meters and the other well (105L) had a drawdown of 12.2 meters; thus the average specific capacity is 0.27 cubic meter per minute per meter of drawdown. Thus, for a pumping rate of 0.94 cubic meter per minute a short-term drawdown of 3.5 meters would be expected in the pumping well (including well entrance losses). Calculated drawdowns in L-Area and in other SRP areas supporting L-Reactor operation are discussed in Sections 4.1.1.3, 5.1.1.4, and 5.2.3.

F.5 GROUND-WATER QUALITY

F.5.1 Natural ground-water quality

A detailed discussion of the natural ground-water quality of the hydro-stratigraphic units is contained in previous sections of this appendix (F.2.1 to F.2.10). Chemical analyses are given in Tables F-2, F-4, and F-5. In general, the water in the coastal plain sediments is of good quality, suitable for industrial and municipal use with minimal treatment. It is generally soft, slightly acidic, and low in dissolved and suspended solids.

F.5.2 L-Area

Previous activities in L-Area have resulted in the discharge of radioactive and nonradioactive wastes into 10 basins and pits in and adjacent to the area. Currently only one of these sites is active (a rubble pit receiving solid waste that is neither radioactive nor hazardous).

Some contamination of the shallow ground water between the L-Area seepage basin and Steel Creek (about 600 meters to the southeast) is expected from the tritium previously discharged to the basin (about 3300 curies). Similarly minor amounts of strontium-90 are expected to have reached the ground water beneath the basin, but confirmation is presently lacking. Monitoring data from around the basin are not yet available; however, monitoring wells have recently been installed.

F.5.3 F- and H-Area seepage basins

Intensive ground-water monitoring studies around the F- and H-Area seepage basins have detected only tritium, strontium-90, and uranium in concentrations greater than 10 times the natural background. Companion studies have shown nitrate and mercury are also present.

TC |

Approximately 30 percent of the tritium discharged to the separations areas seepage basins evaporates to the atmosphere. The remaining tritium moves rapidly to the water table (at a depth of about 3 meters in H-Area and 15 meters in F-Area), and then moves at the same velocity as the ground water. In F-Area, the average flow rate of tritium from the basins to Four Mile Creek is estimated to be 0.15 meter per day (a travel time of 8.9 years to move 600 meters). Approximately 40 percent of the tritium decays before emerging in Four Mile Creek. Concentrations at seepage springs range from 40 to 60 microcuries per liter.*

In H-Area, the flow rate of tritium from the seepage basins to Four Mile Creek is estimated to be 0.3 meter per day (a travel time of 1.1 to 3.8 years). Approximately 10 to 20 percent of the tritium decays before emerging in Four Mile Creek. Concentrations at the seepage springs range up to 40 microcuries per liter.

The maximum vertical penetration of tritium into the ground is about 15 to 20 meters, and throughout most of the distance from the basins to the seepage springs, the highest concentrations are 3 to 6 meters below the water table.

TC |

Strontium, unlike tritium, does not move at the same rate as ground water; its transport is retarded by the clay minerals in the Formation. Thus, it has been emerging into Four Mile Creek from F-Area only since about 1964, and from H-Area since 1959. The amount entering the creek annually is 2 percent of the ground-water load in F-Area and 0.19 percent of the load in H-Area. Under current conditions, F-Area is contributing about 40 times as much strontium to the creek as H-Area because of differing soil retention characteristics. Maximum concentrations of strontium-90 in ground water and emergent seep-lines range up to 0.34 microcurie per liter in F-Area, and 1.8×10^{-3} microcurie per liter in H-Area.

Cesium is retained well by soils at Savannah River Plant, and none has migrated far enough to be detected in ground water between the separations areas seepage basins and Four Mile Creek. Alpha activity in ground water between the F- and H-Area basins and Four Mile Creek is attributed mostly to uranium discharged to the basin plus a small amount of natural radioactivity (plutonium is even more highly immobilized in SRP soils than cesium). Alpha concentrations in ground water and seepage springs range up to 6.5×10^{-3} microcurie per liter in F-Area and 7.5×10^{-6} microcurie per liter in H-Area.

Although most of the mercury released to the separations areas seepage basins is accounted for in the basin soil, studies made in 1971 on soils from the swampy outcrop along Four Mile Creek, bottom sediments, and of suspended solids from the creek show that mercury is slowly migrating into the creek (approximately 0.4 gram per day from both areas).

Nitrate and hydrogen ions are also migrating from the basins. Nitrate concentrations in the ground water measured in 1968 and 1969 ranged to 300 milligrams per liter in F- and H-Area. The pH of ground water in the vicinity of the

*The EPA drinking water standard for tritium is 0.02 microcurie per liter.

basins is 4 to 6 compared to a pH range of 5 to 7 for natural ground water at Savannah River Plant.

Results of 1982 chemical analyses of ground-water samples from monitoring wells at F- and H-Area seepage basins are presented in Tables F-12 and F-13. The locations of these wells are shown in Figure F-34.

TC

F.5.4 M-Area

The M-Area settling basin was constructed in 1958 to settle out and contain uranium discharged in process streams from fuel fabrication facilities. The water discharged to the basin can best be characterized as a metal finishing-type process waste. The process discharges contain, among other things, uranium, aluminum, nitrate, nickel, and chlorinated organics; they can be classified as hazardous only because of the low pH. Waste effluents from M-Area operations have been drained to two process sewers. In May 1982 discharges to Tims Branch were discontinued and diverted instead to the M-Area basin, which now receives all process sewer flows except noncontact cooling water. Some of the process water released to this basin seeps into the ground, but most overflows the basin and seeps into the ground at Lost Lake (shown in Figure F-35).

EN-51

Extensive ground-water monitoring studies around M-Area have been conducted since volatile organics were discovered in the ground water beneath the M-Area basin in June 1981. The distribution of contaminants has been vertically and horizontally determined. A plume of chlorinated hydrocarbons extends about 1 kilometer southwest of the M-Area in 1983. The main body of this plume is moving slowly to the southwest (Figure F-35) at about 7.6 meters per year. Those studies establish that no volatile organics have migrated to the Plant boundary.

Contaminants in the soil beneath the M-Area basin have been characterized by the analyses of cores from coreholes drilled to a depth of about 5 meters below the bottom of the basin. Soil concentrations of lead and mercury ranged up to 125 and 0.16 milligram per kilogram (dry weight), respectively. In all cores, metal concentrations decreased with increasing depth beneath the basin and reached background values in the soil cores at or before 4 feet below the bottom of the basin.

Downward migration rates for metals were calculated using the corresponding depths at which the metal concentrations were equal to background values and a 24-year operation period since startup of the basin in 1958. The calculated migration rates were 0.04 meter per year for lead and 0.05 meter per year for uranium. At these migration rates and under the present operating conditions of the basin, these metals do not pose a significant problem for future contamination of the surrounding ground water. At the present rate of downward movement, it will take the uranium 700 years to travel the 37-meters distance to the ground water.

Soil concentrations of 1,1,1-trichloroethane, trichloroethylene ("tri-clene") and tetrachloroethylene ("perclene") ranged to 11, 90, and 2000 milligrams per kilogram (dry weight), respectively. However, migration rates could not be calculated because of wide variations in concentrations across the M-Area seepage basin.

Table F-12. Results of monitoring well analyses for F-Area seepage basin^a

FSB-76 Upgradient N76137.97 E51386.73 Elev = 294.2						
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		218.2	218.2	218.4	218.7
Coliform B	#/100 ml		0	2	20	5
Color	CU	15	3	30	3	2
Corrosion			No	No	No	No
Odor		3	0	1.4	1	1
pH	pH	6.5-8.5	4.6	4.9	5.0	4.8
Specific Conductivity	µmho/cm		50	56	64	63
TDS	mg/L	500	62	119	42	56
Temp	°C		19.2	19.4	19.7	17.2
Turbidity	1/TU		3.9	1.29	5.1	.2
Ag	mg/L	.05	<.001	<.001	<.001	<.001
As	mg/L	.05	<.002	<.002	<.002	.004
Ba	mg/L	1.0	.112	.44	.07	.12
Be	mg/L		<.010	<.005	<.005	<.005
Cd	mg/L	.01	<.001	.001	<.001	.003
Cr	mg/L	.05	.002	.003	.011	.005
Cu	mg/L	1.0	.004	.005	.012	.011
Fe	mg/L	.3	1.170	12.97	12.01	14.59
Hg	mg/L	.002	<.0002	<.0002	.0004	<.0002
Mn	mg/L	.05	.029	.056	.13	.06
Na	mg/L		11.24	8.74	10.99	14.35
Ni	mg/L		.004	.008	.027	.043
Pb	mg/L	.05	.106	.007	.011	.014
Se	mg/L	.01	<.002	<.002	<.002	<.002
Zn	mg/L	5	.052	.065	<.010	.100
Cl	mg/L	250	3	3	5.1	3.4
CN	mg/L		<.005	<.005	<.005	<.005
F	mg/L	1.6	.11	<.10	<.10	<.01
Foaming agents	mg/L	.5	<.01	<.01	<.01	.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	.05	3.13	4.51	4.81
SO ₄	mg/L	250	<5	35	<5	<5
Gross Alpha	pCi/L	15	.6±.6	1.1±.7	0.4±6.2	1.7
Gross Beta	pCi/L		2±8	8.7±8.1	10.5±8.6	9.3
Ra	pCi/L	5	<.42	.27	.45	.51
DOC	mg/L		7	1.5	4	5.5
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<.002	<.002	<.006	<.002
TOC	mg/L		<1	2.5	4	9.5
TOH	mg/L		.360	.830	.009	.012
Endrin	µg/L	.2	<.009	<.04	<.04	<.04
Lindane	µg/L	4	<.005	<1	<1	<1
Methoxychlor	µg/L	100	<.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<.41	<20	<20	<20
245TP	µg/L	10	<.13	<2	<2	<2

Table F-12. Results of monitoring well analyses for F-Area seepage basin (continued)^a

FSB-77 Downgradient N75128.39 E50716.25 Elev = 273.3

Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		215.0	214.9	215.3	215.3
Coliform B	#/100 ml		16	0	00	2
Color	CU	15	10	>5	>5	50
Corrosion			No	No	No	No
Odor		3	0	1.4	0	1
pH	pH	6.5-8.5	3.8	3.7	3.8	3.8
Specific Conductivity	µmho/cm		707	620	104	13200
TDS	mg/L	500	896	796	829	648
Temp	°C		28	28	28	28
Turbidity	1/TU		1.0	.53	.4	.1
Ag	mg/L	.05	<.001	<.001	<.001	<.001
As	mg/L	.05	<.002	<.002	.004	<.002
Ba	mg/L	1.0	.106	.05	<.05	.08
Be	mg/L		<.010	<.005	<.005	<.005
Cd	mg/L	.01	.060	.049	<.023	.057
Cr	mg/L	.05	.001	.001	.012	.009
Cu	mg/L	1.0	.022	.013	.027	.026
Fe	mg/L	.3	3.239	15.72	21.27	23.6
Hg	mg/L	.002	<.0002	<.0002	.0003	<.0002
Mn	mg/L	.05	1.395	1.442	1.55	1.19
Na	mg/L		76.75	70.5	126.7	95.8
Ni	mg/L		.018	.020	.037	.034
Pb	mg/L	.05	.422	.008	.013	.019
Se	mg/L	.01	<.002	<.002	<.002	<.002
Zn	mg/L	5	.167	.093	<.065	.067
Cl	mg/L	250	4	3	5.6	3.1
CN	mg/L		<.005	<.005	<.005	<.005
F	mg/L	1.6	.19	<.10	.13	.01
Foaming agents	mg/L	.5	<.02	<.01	.02	<.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	81.5	60.2	159.05	91.6
SO ₄	mg/L	250	<5	26	<5	<5
Gross Alpha	pCi/L	15	4.8±1.3	2.5±1	2.22±1.09	8.2
Gross Beta	pCi/L		2003±36	1660±32	2577±41	2829
Ra	pCi/L	5	10.10	14.16	18.95	20.10
DOC	mg/L		4	2.5	4	9.0
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		.004	.006	.009	<.002
TOC	mg/L		6	5.0	1	23.0
TOH	mg/L		.051	.042	.34	.018
Endrin	µg/L	.2	<.009	<.04	<.04	<.04
Lindane	µg/L	4	<.005	<1	<1	<1
Methoxychlor	µg/L	100	<.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<.41	<20	<20	<20
245TP	µg/L	10	<.13	<2	<2	<2

Table F-12. Results of monitoring well analyses for F-Area seepage basin (continued)^a

FSB-78		Downgradient	N74750.0	E50150.00	Elev = 272.5	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		210.9	210.7	210.7	211.0
Coliform B	#/100 ml		0	0	0	0
Color	CU	15	10	>5	>5	20
Corrosion			No	No	No	No
Odor		3	0	1.4	6	4
pH	pH	6.5-8.5	3.1	2.9	2.8	2.7
Specific Conductivity	µmho/cm		1551	1700	1834	15500
TDS	mg/L	500	946	1183	964	1187
Temp	°C		22.2	22.0	23.0	19.6
Turbidity	1/TU		.66	.70	.8	.3
Ag	mg/L	0.05	<.001	<.001	<.001	<.001
As	mg/L	0.05	<.002	<.002	.034	.011
Ba	mg/L	1.0	.157	.34	<.05	.10
Be	mg/L		<.010	<.005	<.005	<.005
Cd	mg/L	0.01	.150	.100	<.047	.044
Cr	mg/L	0.05	.015	.023	.053	.030
Cu	mg/L	1.0	.098	.096	.071	.074
Fe	mg/L	0.3	2.379	5.362	44.02	79.64
Hg	mg/L	0.002	.0015	<.0002	.0340	.0536
Mn	mg/L	0.05	1.714	1.356	.845	.74
Na	mg/L		113.30	102.4	153.6	195.0
Ni	mg/L		.045	.085	.109	.065
Pb	mg/L	0.05	.080	.068	.017	.014
Se	mg/L	0.01	<.002	<.002	.008	<.002
Zn	mg/L	5	.259	.178	.196	.226
Cl	mg/L	250	2	2	5.6	2.3
CN	mg/L		<.005	.013	.006	<.005
F	mg/L	1.6	.73	<.10	.44	.51
Foaming agents	mg/L	0.5	.03	<.01	.04	.01
H ₂ S	mg/L		<1.0	1.0	<1.0	<1.0
NO ₃	mg/L	10	198	159.46	262.4	235.2
SO ₄	mg/L	250	10	7	20	10
Gross Alpha	pCi/L	15	41.3±3.7	35±3.4	19.06±3.14	37.7
Gross Beta	pCi/L		7969±69	6426±68	1116±27	799
Ra	pCi/L	5	14.70	23.23	23.94	15.60
DOC	mg/L		<1	1.5	<1	8.0
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<.002	.017	.011	.022
TOC	mg/L		<1	1.0	1	18.0
TOH	mg/L		.024	.016	.007	.007
Endrin	µg/L	0.2	<.009	<.04	<.04	<.04
Lindane	µg/L	4	<.005	<1	<1	<11.3
Methoxychlor	µg/L	100	<.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<.41	<20	<20	<20
245TP	µg/L	10	<.13	<2	<2	<2

Table F-12. Results of monitoring well analyses for F-Area
seepage basin (continued)^a

FSB-79 Downgradient N73660.00 E50145.00 Elev = 217.7

Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		203.0	202.8	202.9	203.2
Coliform B	#/100 ml		0	0	0	0
Color	CU	15	0	1.4	0	0
Corrosion			No	No	No	No
Odor		3	3.5	4.2	4.6	4.1
pH	pH	6.5-8.5	4.5	5.1	5.4	4.5
Specific Conductivity	µmho/cm		56	29	20	0.63
TDS	mg/L	500	37	110	10	-
Temp	°C		17.8	20.5	21.4	15.9
Turbidity	1/TU		0.49	0.43	1.0	0.6
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	0.092	0.16	0.07	<0.05
Be	mg/L		<0.010	<0.005	<0.005	<0.005
Cd	mg/L	0.01	0.002	0.001	<0.001	0.003
Cr	mg/L	0.05	0.003	0.002	0.003	0.002
Cu	mg/L	1.0	0.006	0.009	<0.002	0.002
Fe	mg/L	0.3	0.499	3.15	2.40	2.57
Hg	mg/L	0.002	0.0003	<0.0002	0.0004	<0.0002
Mn	mg/L	0.05	0.035	0.020	<0.02	0.04
Na	mg/L		4.11	2.05	2.45	8.95
Ni	mg/L		0.002	0.006	0.008	0.008
Pb	mg/L	0.05	0.020	0.003	0.005	0.002
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.016	0.025	<0.010	0.019
Cl	mg/L	250	3	3	3.4	2.6
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	0.10	0.50	<0.10	<.01
Foaming agents	mg/L	0.5	0.02	0.02	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	4.31	0.39	0.69	3.71
SO ₄	mg/L	250	<5	21	<5	<5
Gross Alpha	pCi/L	15	0.8±0.6	3.9±1.2	0.74±0.66	0.9
Gross Beta	pCi/L		25±9	51.2±95	7.5±8.4	57
Ra	pCi/L	5	2.63	0.47	0.50	0.26
DOC	mg/L		5	<1.0	1	9.0
GC	µg/L		<40	<40	139	<40
Phenols	mg/L		<0.002	<0.002	0.007	<0.002
TOC	mg/L		3	<1.0	2	9.0
TOH	mg/L		0.120	0.850	0.026	0.012
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<21
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<1	<2	<2

^aAdapted from Du Pont, 1983.

Table F-13. Results of monitoring well analyses for H-Area seepage basins^a

HSB-65		Upgradient N72424.25 E58433.00 Elev = 271.9				
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		237.1	236.4	237.5	236.9
Coliform B	#/100 ml		0	0	0	0
Color	CU	15	3	3	5	2
Corrosion			No	No	No	No
Odor		3	1.4	1.4	0	2
pH	pH	6.5-8.5	3.9	5.4	4.8	4.3
Specific Conductivity	µmho/cm		48	48	54	45
TDS	mg/L	500	64	19	43	22
Temp	°C		18.0	17.6	19.9	16.3
Turbidity	1/TU		1.7	1.2	0.6	0.3
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	0.005	0.021
Ba	mg/L	1.0	0.218	0.05	<0.05	0.24
Be	mg/L		<0.010	0.31	<0.005	0.012
Cd	mg/L	0.01	0.002	<0.001	<0.001	0.009
Cr	mg/L	0.05	0.021	0.062	0.031	0.043
Cu	mg/L	1.0	0.022	0.046	0.024	0.075
Fe	mg/L	0.3	19.89	8.07	24.54	90.98
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	0.177	0.560	0.15	0.56
Na	mg/L		3.08	2.78	3.54	6.09
Ni	mg/L		0.018	0.054	0.029	0.025
Pb	mg/L	0.05	0.027	0.048	0.047	0.062
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.095	0.283	0.075	0.278
Cl	mg/L	250	5	4	4.4	3.3
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.10	0.12	<0.10	<0.01
Foaming agents	mg/L	0.5	<0.01	0.02	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	2.36	2.39	2.63	3.21
SO ₄	mg/L	250	<5	26	<5	<5
Gross Alpha	pCi/L	15	3.4±1.1	1.8±0.7	1.27±0.84	-
Gross Beta	pCi/L		18±8	52±45	21.2±8.9	-
Ra	pCi/L	5	<0.38	0.20	0.41	0.50
DOC	mg/L		8	1.5	2	9.0
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		0.004	<0.002	0.006	<0.002
TOC	mg/L		6	2.0	4	9.5
TOH	mg/L		0.010	0.026	0.017	0.007
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)^a

HSB-66

Upgradient N72429.63 E56928.59 Elev = 280.1

Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		230.9	230.1	231.4	229.4
Coliform B	#/100 ml		5	0	0	5
Color	CU	15	10	3	5	2
Corrosion			No	No	No	No
Odor		3	50	2	0	0
pH	pH	6.5-8.5	4.0	6.3	5.4	4.1
Specific Conductivity	µmho/cm		24	26	25	22
TDS	mg/L	500	32	19	36	5
Temp	°C		19.6	19.5	20.8	16.3
Turbidity	1/TU		0.59	0.86	1.1	0.7
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.05	<0.05	0.7	<0.05
Be	mg/L		<0.010	0.014	<0.005	<0.005
Cd	mg/L	0.01	0.001	0.001	<0.001	0.032
Cr	mg/L	0.05	0.002	0.002	0.007	0.002
Cu	mg/L	1.0	0.002	0.006	0.006	0.004
Fe	mg/L	0.3	0.140	0.12	0.70	0.94
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	0.020	0.020	<0.02	0.03
Na	mg/L		2.68	2.17	2.87	5.35
Ni	mg/L		0.002	0.009	0.010	0.020
Pb	mg/L	0.05	0.857	0.005	0.010	0.028
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.078	0.078	0.080	0.060
Cl	mg/L	250	3	3	3.7	2.8
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.15	0.11	<0.10	<0.01
Foaming agents	mg/L	0.5	0.02	<0.01	0.02	0.03
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	1.19	3.01	0.95	0.91
SO ₄	mg/L	250	<5	22	<5	<5
Gross Alpha	pCi/L	15	1.2±0.7	0.5±0.4	0.37±0.5	1.2
Gross Beta	pCi/L		5±8	1.7±6.5	6.2±8.4	6.8
Ra	pCi/L	5	<0.43	0.40	2.83	0.33
DOC	mg/L		8	1.5	3	6.5
GC	µg/L		<40	-	<40	<40
Phenols	mg/L		<0.002	<0.002	0.003	<0.002
TOC	mg/L		4	4.0	3	11.5
TOH	mg/L		0.013	0.025	19.0	0.011
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)^a

HSB-67		Downgradient	N71499.98	E58409.98	Elev = 237.6	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		228.6	228.1	228.6	228.6
Coliform B	#/100 ml		0	0	0	0
Color	CU	15	2	3	7	2
Corrosion			No	No	No	No
Odor		3	0	0	12	0
pH	pH	6.5-8.5	3.6	4.4	4.2	4.2
Specific Conductivity	umho/cm		180	54	80	87
TDS	mg/L	500	156	54	52	52
Temp	°C		17.8	20.4	21.5	13.5
Turbidity	1/TU		56	0.89	0.4	3.9
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	0.080	0.08	<0.05	<0.05
Be	mg/L		<0.005	<0.005	<0.005	<0.005
Cd	mg/L	0.01	0.002	<0.001	<0.001	<0.002
Cr	mg/L	0.05	0.004	0.002	0.007	0.004
Cu	mg/L	1.0	0.004	0.002	0.003	0.002
Fe	mg/L	0.3	2.548	2.91	1.61	1.75
Hg	mg/L	0.002	0.0458	0.0092	0.0074	0.0067
Mn	mg/L	0.05	0.056	<0.020	<0.02	0.05
Na	mg/L		33.75	6.13	12.91	16.40
Ni	mg/L		0.004	<0.002	0.005	0.015
Pb	mg/L	0.05	0.008	0.002	0.011	0.004
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.072	0.066	0.048	0.042
Cl	mg/L	250	5	3	4.2	4.6
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.10	<0.10	<0.10	<0.01
Foaming agent	mg/L	0.5	0.03	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	19.5	4.26	7.89	8.71
SO ₄	mg/L	250	<5	16	<5	<5
Gross Alpha	pCi/L	15	4.9±1.3	1.2±0.6	1.11±0.79	1.2
Gross Beta	pCi/L		1009±26	93.5±9.1	96.2±11.2	154
Ra	pCi/L	5	3.81	1.38	<0.39	0.97
DOC	mg/L		7	1.5	2	6.0
GC	ug/L		<40	70	<40	<40
Phenols	mg/L		<0.002	<0.002	0.007	<0.002
TOC	mg/L		6	3.5	5	9.0
TOH	mg/L		0.100	0.068	0.110	0.047
Endrin	ug/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	ug/L	4	<0.005	<1	<1	<1
Methoxychlor	ug/L	100	<0.06	<20	<20	<20
Toxaphene	ug/L	5	<1.04	<1	<1	<1
24D	ug/L	100	<0.41	<20	<20	<20
245TP	ug/L	10	<0.13	<2	<2	<2

Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)a

HSB-68 Downgradient N73660.00 E50145.00 Elev = 217.7						
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		226.4	226.0	226.3	226.5
Coliform B	#/100 ml		0	0	0	1800
Color	CU	15	2	>5	>5	2
Corrosion			No	No	No	No
Odor		3	0	1.4	0	4
pH	pH	6.5-8.5	3.1	4.2	4.0	5.1
Specific Conductivity	µmho/cm		160	170	174	418
TDS	mg/L	500	148	141	116	39
Temp	°C		12.6	20.1	19.9	15.5
Turbidity	1/TU		100	8.5	0.5	0.3
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	0.005	<0.002
Ba	mg/L	1.0	<0.05	0.78	<0.05	0.14
Be	mg/L		<0.010	0.035	<0.005	<0.005
Cd	mg/L	0.01	0.002	<0.001	0.001	0.010
Cr	mg/L	0.05	0.017	0.008	0.047	0.051
Cu	mg/L	1.0	0.004	0.004	0.016	0.017
Fe	mg/L	0.3	45.78	172	139.6	231.6
Hg	mg/L	0.002	0.0048	0.0058	0.0039	0.0087
Mn	mg/L	0.05	0.762	1.277	0.51	1.19
Na	mg/L		60.10	50.4	27.53	101.6
Ni	mg/L		0.009	0.015	0.019	0.021
Pb	mg/L	0.05	0.025	0.018	0.043	0.029
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.074	0.120	0.180	0.219
Cl	mg/L	250	4	2	3.6	3.5
CN	mg/L		<0.005	<0.008	<0.005	<0.005
F	mg/L	1.6	0.10	<0.10	<0.10	<0.01
Foaming agents	mg/L	0.5	0.02	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	18.8	30.1	68.5	65.31
SO ₄	mg/L	250	<5	27	<5	<5
Gross Alpha	pCi/L	15	3.2±1.1	6.1±1.3	4.54±1.55	3.2
Gross Beta	pCi/L		1280±29	1502±28	1824±35	14.9
Ra	pCi/L	5	5.37	12.18	1.06	6.06
DOC	mg/L		5	<1.0	3	11.5
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<0.002	0.010	0.016	<0.002
TOC	mg/L		7	8.5	10	20.0
TOH	mg/L		0.280	0.018	<0.005	0.012
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	1.8
Methoxychlor	µg/L	100	<0.06	<20	<201	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)^a

HSB-69 Downgradient N72550.00 E56400.00 Elev = 235.8						
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		222.3	216.9	222.8	222.7
Coliform B	#/100 ml		0	0	0	20
Color	CU	15	5	3	7	2
Corrosion			No	No	No	No
Odor		3	0	2	0	0
pH	pH	6.5-8.5	3.6	4.5	4.4	4.1
Specific Conductivity	µmho/cm		80	18	25	86
TDS	mg/L	500	68	22	18	81
Temp	°C		16.3	18.9	21.2	14.6
Turbidity	1/TU		1.4	1.2	1.0	0.1
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.05	0.24	0.06	0.18
Be	mg/L		<0.010	0.014	<0.005	<0.005
Cd	mg/L	0.01	0.001	<0.001	<0.001	<0.005
Cr	mg/L	0.05	0.009	0.002	0.004	0.006
Cu	mg/L	1.0	0.007	0.002	0.002	0.006
Fe	mg/L	0.3	9.55	24.65	7.30	16.35
Hg	mg/L	0.002	0.006	<0.003	0.006	0.006
Mn	mg/L	0.05	0.048	0.081	0.12	0.05
Na	mg/L		18.04	102.1	4.16	17.40
Ni	mg/L		0.005	0.010	0.009	0.016
Pb	mg/L	0.05	<0.001	0.006	0.008	0.009
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.101	0.095	<0.010	0.131
Cl	mg/L	250	3	2	3.4	2.1
CN	mg/L		<0.005	0.005	<0.005	<0.005
F	mg/L	1.6	0.10	<0.10	<0.10	<0.01
Foaming agents	mg/L	0.5	0.01	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	8.83	1.13	0.51	9.11
SO ₄	mg/L	250	<5	16	<5	<5
Gross Alpha	pCi/L	15	1.2±0.7	1.6±0.7	0.69±0.64	0.8
Gross Beta	pCi/L		36±9	16.3±7.0	19.1±8.9	21.4
Ra	pCi/L	5	1.32	0.91	<0.46	1.61
DOC	mg/L		7	1.5	3	6.0
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<0.002	<0.002	0.004	<0.002
TOC	mg/L		8	2.0	3	12.0
TOH	mg/L		0.009	0.022	5.3	0.010
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

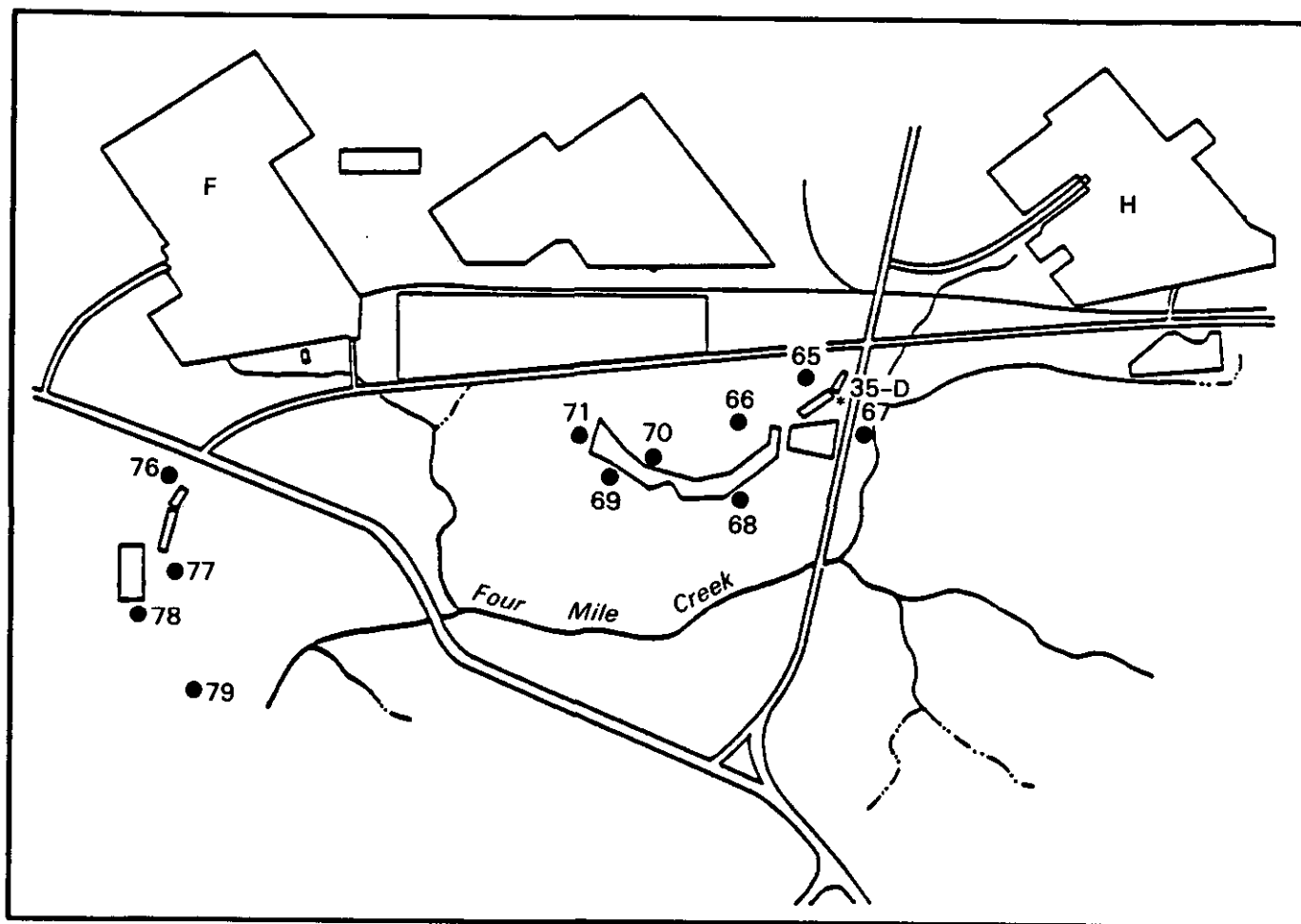
Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)a

HSB-70 Upgradient N72600.00 E55760.00 Elev = 242.5						
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		229.9	231.0	231.0	231.2
Coliform B	#/100 ml		0	0	8	32
Color	CU	15	5	2	10	0
Corrosion			No	No	No	No
Odor		3	50	0	10	0
pH	pH	6.5-8.5	3.9	4.5	4.7	4.7
Specific Conductivity	µmho/cm		36	40	31	35
TDS	mg/L	500	35	101	18	38
Temp	°C		17.8	23.1	21.2	13.2
Turbidity	1/TU		1.2	1.4	2.0	0.7
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.05	0.10	<0.05	0.32
Be	mg/L		<0.010	<0.010	<0.005	<0.005
Cd	mg/L	0.01	<0.001	<0.001	<0.001	0.002
Cr	mg/L	0.05	<0.004	0.10	0.002	0.008
Cu	mg/L	1.0	0.008	0.004	<0.002	0.002
Fe	mg/L	0.3	11.64	8.452	0.75	3.56
Hg	mg/L	0.002	<0.0002	<0.0002	0.0004	<0.0002
Mn	mg/L	0.05	<0.02	0.023	<0.02	0.06
Na	mg/L		1.66	1.04	1.48	2.98
Ni	mg/L		0.003	<0.001	0.007	0.039
Pb	mg/L	0.05	0.004	0.002	0.003	0.001
Se	mg/L	0.01	<0.002	0.002	<0.002	<0.002
Zn	mg/L	5	0.044	0.016	0.057	0.090
Cl	mg/L	250	2	2	2.8	1.4
CN	mg/L		0.006	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.10	0.10	<0.10	<0.01
Foaming agents	mg/L	0.5	0.02	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	0.13	0.29	0.12	0.31
SO ₄	mg/L	250	<5	7.5	10	<5
Gross Alpha	pCi/L	15	0.7±0.6	0.7±0.7	0.74±0.66	0.9
Gross Beta	pCi/L		5±8	6.5±8.2	10.3±8.6	12.5
Ra	pCi/L	5	<0.33	<0.20	<0.41	0.57
DOC	mg/L		7	1	3	10.0
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<0.002	<0.002	0.004	<0.002
TOC	mg/L		5	4	5	17.5
TOH	mg/L		0.037	0.046	0.013	0.006
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

Table F-13. Results of monitoring well analyses for H-Area seepage basin (continued)^a

HSB-71 Downgradient N73660.00 E50145.00 Elev = 217.7						
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		226.1	225.8	226.3	226.1
Coliform B	#/100 ml		0	2	0	3
Color	CU	15	3	2	5	2
Corrosion			No	No	No	No
Odor		3	0	0	0	0
pH	pH	6.5-8.5	4.2	4.4	4.6	4.4
Specific Conductivity	µmho/cm		69	41	34	18
TDS	mg/L	500	86	113	13	28
Temp	°C		17.1	20.4	21.4	13.5
Turbidity	1/TU		1.1	1.86	3.6	7.9
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	0.148	0.18	<0.05	0.13
Be	mg/L		<0.010	<0.010	<0.005	<0.005
Cd	mg/L	0.01	<0.001	<0.001	<0.001	0.005
Cr	mg/L	0.05	0.005	0.014	0.003	0.003
Cu	mg/L	1.0	0.011	0.007	0.004	0.003
Fe	mg/L	0.3	0.987	1.008	0.59	1.33
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	<0.02	0.053	0.06	<0.02
Na	mg/L		11.34	12.04	4.34	6.53
Ni	mg/L		<0.001	0.016	0.009	0.011
Pb	mg/L	0.05	<0.001	0.016	0.005	0.010
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	0.067	0.115	0.049	0.077
Cl	mg/L	250	4	3	3.9	1.2
CN	mg/L		0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	0.10	0.11	<0.10	<0.01
Foaming agents	mg/L	0.5	0.02	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	5.31	2.51	1.07	0.21
SO ₄	mg/L	250	<5	7.5	<5	<5
Gross Alpha	pCi/L	15	0.9±0.7	0.5±0.6	0.37±0.5	0.4
Gross Beta	pCi/L		18±8	3.3±8.1	7.4±8.4	0.9
Ra	pCi/L	5	<0.43	<0.32	<0.37	0.18
DOC	mg/L		7	6	3	6.5
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<0.002	<0.002	0.005	<0.002
TOC	mg/L		6	4	3	11.5
TOH	mg/L		0.037	0.270	0.011	0.011
Endrin	µg/L	0.2	<0.009	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.005	<1	<1	<1
Methoxychlor	µg/L	100	<0.06	<20	<20	<20
Toxaphene	µg/L	5	<1.04	<1	<1	<1
24D	µg/L	100	<0.41	<20	<20	<20
245TP	µg/L	10	<0.13	<2	<2	<2

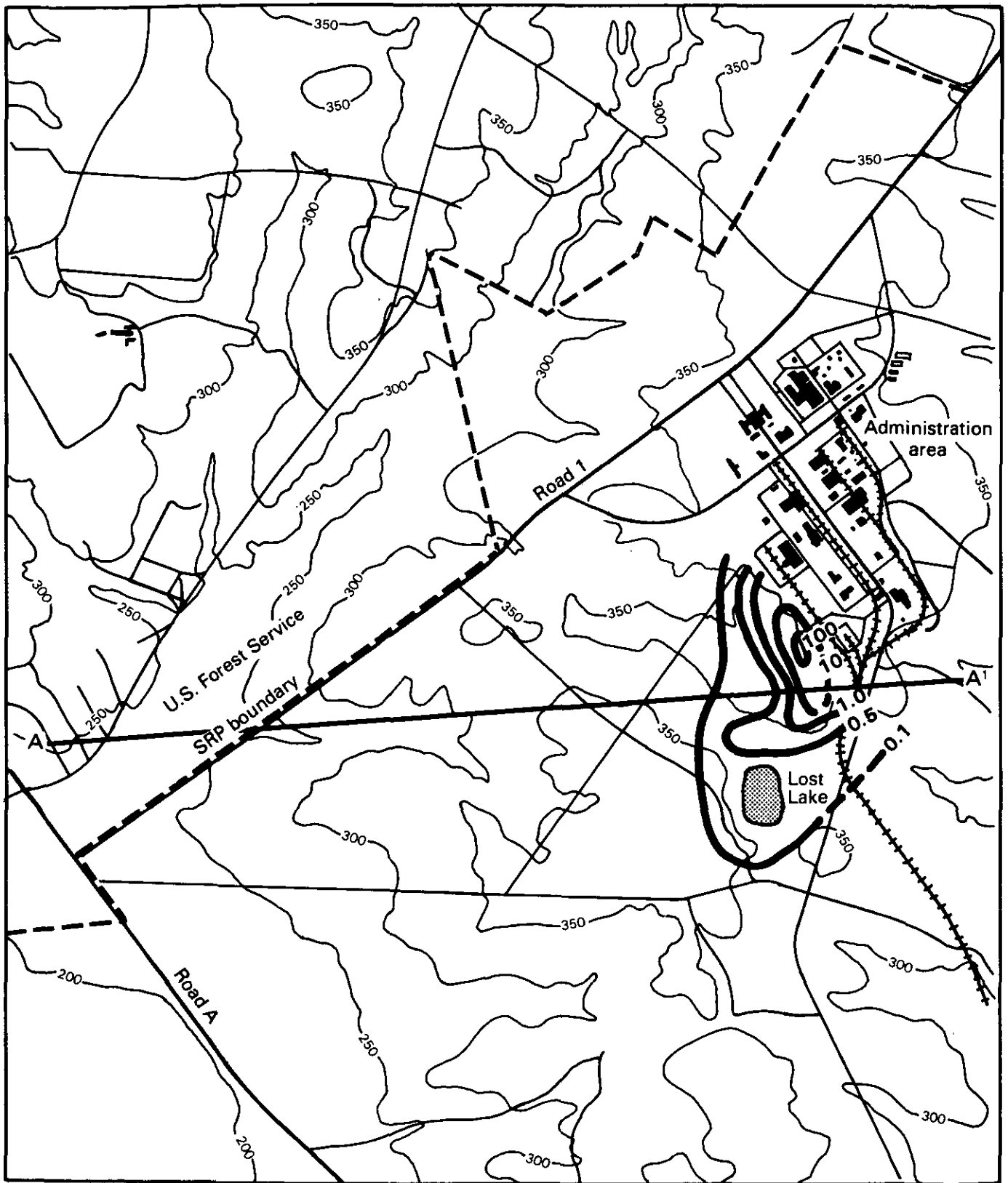
^aAdapted from Du Pont, 1983



Legend:

- Monitoring well
See Tables F-12 and F-13 for monitoring results.
- *Monitoring well 35-D (Marine, 1965)

Figure F-34. Location of FSB (F-Area) and HSB (H-Area) hazardous-waste monitoring wells.



Source: Du Pont (1983).

Figure F-35. Contours of total organic degreaser concentrations from ground-water analyses (mg/l).

Trichloroethane, the last of the three chlorinated organics discharged to the settling basin, was detected at the 15-foot depth and is known to be present in the ground water; perclene was also detected in the bottom sections of all five cores and has been found in high concentrations in the ground water near the basin.

Figure F-35 shows the distribution of total organic degreasers in the horizontal dimension west of the M-Area settling basin and process effluent sewer. Figure F-36 shows the extent of the contamination in a vertical section. Using the contours and from the investigation of the basin and discharge pipeline, the quantity of volatile organics in the ground water in this area is estimated at about 27,000 kilograms. From soil cores an additional 24,000 kilograms is estimated to reside in the unsaturated zone beneath the surface sources of contamination. (See Du Pont 1982, for additional details.)

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Tables F-14 and F-15 give analyses of other constituents in the ground water from the Tertiary aquifers in M-Area. Figure F-37 shows the locations of these monitoring wells. A high nitrate content is characteristic of the center of the organics plume and exceeds drinking water standards. Other ground-water constituents are within drinking water limits.

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Wells in neighboring A-Area (Figure F-37) that draw from the Tuscaloosa Formation (especially wells 53A and 20A) were found to have small quantities of chlorinated hydrocarbons, in concentrations from a few to about 27 micrograms per liter (Du Pont, 1983; Geraghty and Miller, 1983). The entry of chlorinated hydrocarbons into these wells might have resulted from the migration of the contaminants from Tertiary (shallow) aquifers down the well annuli to the well screens, and not from any M-Area-related contamination of the Tuscaloosa that has migrated through the overlying basal Congaree and upper Ellenton clay units. This hypothesis is being investigated through geophysical examinations of old production wells and through the monitoring of the water quality of new wells. Chlorinated hydrocarbons above the limit of detection (1 microgram per liter) have not been found in recent M- and A-Area wells drilled to monitor Tuscaloosa water quality and water levels. One of these new wells is within 80 meters of the A-Area production well (53A) that exhibited the highest concentrations of chlorinated hydrocarbons. Recent analysis of water from well 53A showed no evidence of such volatile organics as chlorinated hydrocarbons (Steele, 1983). A cement bond log of well 53A indicated extensive areas where the cement sheath around the casing was not bound to the casing. Such areas of poor bond would provide avenues for contaminated water from the Tertiary to migrate directly to the screen sections of the Tuscaloosa (Geraghty and Miller, 1983). These determinations lend support to the hypothesis that A-Area wells received contamination from ground water that entered from the shallow aquifers and not from the Tuscaloosa Aquifer.

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F.5.5 Burial ground

Ground-water quality at the SRP burial ground is being extensively studied with monitoring wells located inside and adjacent to the burial site. Monitoring for radionuclides and mercury has shown that only tritium has reached the ground water in significant amounts after 30 years of operations. Average

Table F-14. Inorganic chemistry of ground water in the vicinity of M-Area basin^a

Constituent	Concentration (mg/ l)	
	Average background (6 wells)	Average downgradient ^b (6 wells)
K	5.6	7.7
Na	7.2	33.7
Ca	40.7	68.5
Mg	.38	8.3
Cl	2.1	4.7
SO ₄	2.5	2.2
P	37	34
N (NO ₂ + NO ₃ as N)	.9	56
Fe ^b	1.4	.7
Zn ^b	.35	4.0
Ni ^b	<.01	.06
Al ^b	3.7	1.8
Cu ^b	.07	.04
<u>Property</u>		
Conductivity (μmho/cm)	337	554
pH	9.2	8.76

^aPVC wells only (background, 4 wells; downgradient, 5 wells); adapted from Du Pont (1983).

^bWells within 300 meters of basin.

Table F-15. Results of monitoring well analyses for M-Areaa

MSB-1		Background	N101824.23 N101824.2	E48468.50 E48486.1	Elev = 352.53 (83) Elev = 353.4 (82)	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		244.4	243.9	243.6	242.0
Coliform B	#/100 ml		0	0	0	4
Color	CU	15	3	3	5	2
Corrosion			No	No	No	No
Odor		3	0	0	0	0
pH	pH	6.5-8.5	7.6	8.6	6.0	4.5
Specific Conductivity	µmho/cm		153	112	118	60
TDS	mg/L	500	107	71	87	20
Temp	°C		18.7	21.6	18.9	17.8
Turbidity	1/TU		7.5	3.4	0.1	0.2
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	0.003	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.05	<0.05	0.49	<0.05
Be	mg/L		<0.005	<0.010	<0.005	<0.005
Cd	mg/L	0.01	0.004	0.008	0.004	0.006
Cr	mg/L	0.05	0.010	0.003	0.024	0.039
Cu	mg/L	1.0	0.011	0.008	0.025	0.008
Fe	mg/L	0.3	1.20	1.185	16.86	93.42
Hg	mg/L	0.002	0.0002	<0.0002	0.0002	<0.0002
Mn	mg/L	0.05	0.016	0.033	0.25	0.16
Na	mg/L		14.30	15.70	9.32	6.49
Ni	mg/L		0.010	0.009	0.020	0.014
Pb	mg/L	0.05	0.158	0.082	0.152	0.015
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	20.28	11.46	18.08	0.751
Cl	mg/L	250	4	4.6	3.5	2.3
CN	mg/L		0.012	<0.005	<0.005	<0.005
F	mg/L	1.6	0.14	0.15	0.13	0.01
Foaming agents	mg/L	0.5	<0.01	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	0.8	3.29	3.75	3.01
SO ₄	mg/L	250	<5	<5	5	<5
Gross Alpha	pCi/L	15	0.3±0.4	0.7±0.6	0.74±0.59	2.2
Gross Beta	pCi/L		4±8	10.1±8.1	0.45±7.51	3.1
Ra	pCi/L	5	<0.18	<0.45	0.51	0.77
DOC	mg/L		5	4	2	5.5
GC	µg/L		<40	56	<40	129
Phenols	mg/L		<0.002	<0.002	0.003	<0.002
TOC	mg/L		4	2	5	21.3
TOH	mg/L		0.970	0.400	216	0.21
Endrin	µg/L	0.2	<54	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.17	<1	<1	<1
Methoxychlor	µg/L	100	<2.5	<20	<20	<20
Toxaphene	µg/L	5	<6.0	<1	<1	<1
24D	µg/L	100	<0.31	<20	<20	<20
245TP	µg/L	10	<0.14	<2	<2	<2

Table F-15. Results of monitoring well analyses for M-Area
(continued)^a

MSB-2		Downgradient		N102021.39	E487545.98	Elev = 351.72
				N101999.2	E48741.9	Elev = 352.3
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		240.8	241.9	241.8	241.7
Coliform B	#/100 ml		0	0	100	33
Color	CU	15	5	5	5	2
Corrosion			No	No	No	No
Odor		3	2	1	0	4
pH	pH	6.5-8.5	5.6	7.1	6.3	3.4
Specific Conductivity	µmho/cm		181	202	209	
TDS	mg/L	500	104	136	157	38
Temp	°C		19.0	20.3	19.2	17.5
Turbidity	1/TU		13.6	14.4	0.1	0.1
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	0.003	<0.002	0.006	<0.002
Ba	mg/L	1.0	<0.05	0.21	0.18	0.06
Be	mg/L		<0.005	<0.010	<0.005	<0.005
Cd	mg/L	0.01	0.014	0.019	0.022	0.011
Cr	mg/L	0.05	0.075	0.022	0.115	0.031
Cu	mg/L	1.0	0.010	0.044	0.107	0.011
Fe	mg/L	0.3	18.24	12.34	111.4	56.72
Hg	mg/L	0.002	0.0002	<0.0002	0.0006	<0.0002
Mn	mg/L	0.05	0.424	1.615	3.09	0.08
Na	mg/L		18.74	19.42	24.49	6.32
Ni	mg/L		0.042	0.039	0.032	0.018
Pb	mg/L	0.05	0.026	0.032	0.065	0.021
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	2.815	1.316	5.25	0.276
Cl	mg/L	250	3	5.8	3.4	30.6
CN	mg/L		0.013	<0.005	0.007	<0.005
F	mg/L	1.6	<0.10	0.20	0.13	0.05
Foaming agents	mg/L	0.5	<0.01	0.20	0.04	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	0.30	3.16	3.01	6.23
SO ₄	mg/L	250	<5	<5	5	90
Gross Alpha	pCi/L	15	3.2±1.1	2.0±0.9	1.98±0.9	4.8
Gross Beta	pCi/L		7±8	10.4±8.1	9.53±8.52	2.2
Ra	pCi/L	5	1.17	1.08	0.97	4.14
DOC	mg/L		19	6	6	7.0
GC	µg/L		280	206	197	1217
Phenols	mg/L		<0.002	0.014	0.003	<0.002
TOC	mg/L		16	14	39	36.8
TOH	mg/L		0.190	4.7	50	2.1
Endrin	µg/L	0.2	<0.54	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.17	<1	<1	<1
Methoxychlor	µg/L	100	<2.5	<20	<20	<20
Toxaphene	µg/L	5	<6.0	<1	<1	<1
24D	µg/L	100	<0.31	<20	<20	<20
245TP	µg/L	10	<0.14	<2	<2	<2

Table F-15. Results of monitoring well analyses for M-Area
(continued)a

MSB-3		Downgradient	N102181.57 N102181.6	E48552.08 E48530.7	Elev = 359.03 Elev = 359.6	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		242.6	243.1	243.2	242.0
Coliform B	#/100 ml		0	0	0	0
Color	CU	15	7	5	70	5
Corrosion			No	No	No	No
Odor		3	2	2	165	128
pH	pH	6.5-8.5	4.9	5.7	5.8	3.8
Specific Conductivity	µmho/cm		206	496	300	1248
TDS	mg/L	500	147	507	355	877
Temp	°C		19.8	22.7	19.4	18.9
Turbidity	1/TU		7.4	2.1	2.6	0.3
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	0.07	0.35	<0.05	0.05
Be	mg/L		<0.005	<0.010	<0.005	<0.005
Cd	mg/L	0.01	0.008	0.090	0.258	0.026
Cr	mg/L	0.05	0.100	0.029	0.052	0.025
Cu	mg/L	1.0	<0.002	0.014	0.015	0.030
Fe	mg/L	0.3	33.42	29.17	34.74	49.10
Hg	mg/L	0.002	0.0010	<0.0002	0.003	<0.0002
Mn	mg/L	0.05	0.674	1.331	0.74	0.56
Na	mg/L		11.70	12.04	93.79	230.0
Ni	mg/L		0.084	0.079	0.179	0.042
Pb	mg/L	0.05	0.043	0.039	0.051	0.008
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002
Zn	mg/L	5	5.020	7.566	3.71	0.373
Cl	mg/L	250	4	7.7	13.8	16.3
CN	mg/L		0.028	<0.005	0.011	0.077
F	mg/L	1.6	0.13	<0.10	0.14	0.63
Foaming agents	mg/L	0.5	<0.01	<0.01	<0.01	0.09
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	10.62	4.18	54.35	129.4
SO ₄	mg/L	250	<5	<5	10	<5
Gross Alpha	pCi/L	15	5.3±1.4	0.2±0.4	2.8±1.04	1.7
Gross Beta	pCi/L		32±9	7.3±8.3	19.7±8.9	8.3
Ra	pCi/L	5	3.07	7.99	4.61	9.96
DOC	mg/L		11	9	10	4.2
GC	µg/L		81070	70835	41882	85870
Phenols	mg/L		0.056	0.031	0.040	0.024
TOC	mg/L		27	23	1100	100.5
TOH	mg/L		6.200	16.0	64	78.0
Endrin	µg/L	0.2	<1.4	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.2	<1	<1	<1
Methoxychlor	µg/L	100	<7.3	<20	<20	<20
Toxaphene	µg/L	5	<60.0	<1	<1	<1
24D	µg/L	100	<0.31	<20	<20	<20
245TP	µg/L	10	<0.14	<2	<2	4.5

Table F-15. Results of monitoring well analyses for M-Area
(continued)^a

MSB-4		Downgradient		N101982.66	E48312.57	Elev = 354.05	
				N102010.4	E48313.8	Elev = 355.1	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83	
Water Table Elevation	Ft		242.6	242.7	243.6	242.0	
Coliform B	#/100 ml		0	0	500	27	
Color	CU	15	-	3	3	5	
Corrosion			No	No	No	No	
Odor		3	4	2	1	32	
pH	pH	6.5-8.5	-	-	5.3	4.3	
Specific Conductivity	umho/cm		-	147	186	116	
TDS	mg/L	500	-	98	109	110	
Temp	°C		-	-	19.1	17.0	
Turbidity	1/TU		-	3.1	2.2	0.4	
Ag	mg/L	0.05	0.001	<0.001	<0.001	<0.001	
As	mg/L	0.05	<0.002	<0.002	0.004	<0.002	
Ba	mg/L	1.0	0.21	0.17	0.06	<0.05	
Be	mg/L		0.017	<0.010	<0.005	<0.005	
Cd	mg/L	0.01	0.040	0.042	0.024	0.012	
Cr	mg/L	0.05	0.649	0.096	0.179	0.041	
Cu	mg/L	1.0	0.240	0.477	0.109	0.019	
Fe	mg/L	0.3	201.0	80.35	92.8	104.1	
Hg	mg/L	0.002	0.0002	0.1025	0.0136	<0.0002	
Mn	mg/L	0.05	0.963	0.950	0.88	0.40	
Na	mg/L		0.99	1.04	15.77	11.03	
Ni	mg/L		0.301	0.297	0.090	0.024	
Pb	mg/L	0.05	0.639	0.265	0.437	0.010	
Se	mg/L	0.01	<0.002	<0.002	<0.002	<0.002	
Zn	mg/L	5	43.0	11.24	21.78	0.293	
Cl	mg/L	250	-	4.0	3.5	4.8	
CN	mg/L		0.018	<0.005	0.006	<0.005	
F	mg/L	1.6	<0.1	0.17	0.27	0.01	
Foaming agents	mg/L	0.5	<0.01	0.02	0.22	<0.01	
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0	
NO ₃	mg/L	10	0.61	0.43	3.63	10.11	
SO ₄	mg/L	250	<5	<5	5	<5	
Gross Alpha	pCi/L	15	12.9±2.1	0.5±0.5	1.9±0.86	5.7	
Gross Beta	pCi/L		59±10	3.9±8.2	10.6±8.6	16.7	
Ra	pCi/L	5	1.80	1.66	1.32	1.83	
DOC	mg/L		7	15	32	5.3	
GC	ug/L		170	166	126	177	
Phenols	mg/L		0.035	<0.002	<0.002	<0.002	
TOC	mg/L		28	14	140	96.0	
TOH	mg/L		0.170	0.520	0.17	0.74	
Endrin	ug/L	0.2	<0.014	<0.04	<0.04	<0.04	
Lindane	ug/L	4	<0.002	<1	<1	<1	
Methoxychlor	ug/L	100	<0.073	<20	<20	<20	
Toxaphene	ug/L	5	<0.61	<1	<1	<1	
24D	ug/L	100	<0.31	<20	<20	<20	
245TP	ug/L	10	<0.14	<2	<2	<2	

Table F-15. Results of monitoring well analyses for M-Area
(continued)^a

MSB-5		Downgradient	N101948.21 N101768.7	E46998.81 E46983.8	Elev = 343.63 (83) Elev = 339.1 (82)	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		240.1	240.9	234.1	238.1
Coliform B	#/100 ml		0	0	16	79
Color	CU	15	30	7	10	2
Corrosion			No	No	No	No
Odor		3	6	4	14	1
pH	pH	6.5-8.5	5.2	5.9	6.1	5.0
Specific Conductivity	umho/cm		134	185	69	173
TDS	mg/L	500	100	143	175	137
Temp	°C		18.1	21.0	17.4	15.3
Turbidity	1/TU		12.0	79	10.0	0.4
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	0.002	<0.002
Ba	mg/L	1.0	<0.05	<0.050	0.06	<0.05
Be	mg/L		<0.010	<0.010	<0.005	<0.005
Cd	mg/L	0.01	0.017	0.004	0.002	0.006
Cr	mg/L	0.05	0.004	0.037	0.027	0.027
Cu	mg/L	1.0	0.021	0.048	0.007	0.007
Fe	mg/L	0.3	7.68	29.04	53.04	49.64
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	0.536	0.791	0.13	0.21
Na	mg/L		25.74	24.07	40.2	34.0
Ni	mg/L		0.010	0.009	0.022	0.018
Pb	mg/L	0.05	0.034	0.080	0.013	0.019
Se	mg/L	0.01	<0.002	0.002	<0.002	<0.002
Zn	mg/L	5	4.120	8.78	0.139	0.134
Cl	mg/L	250	5	8.1	4.1	4.6
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.10	<0.10	0.10	0.03
Foaming agents	mg/L	0.5	<0.01	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	5.252	7.76	8.57	18.31
SO ₄	mg/L	250	<5	10	12	<5
Gross Alpha	pCi/L	15	3.7±1.2	3.9±1.2	1.5±0.8	1.1
Gross Beta	pCi/L		14±9	4.2±8.2	9.0±8.2	2.6
Ra	pCi/L	5	0.46	0.82		0.90
DOC	mg/L		4	5	4	5.3
GC	ug/L		<40	<40	<40	<40
Phenols	mg/L		0.004	0.002	0.003	<0.002
TOC	mg/L		6	16	11	16.0
TOH	mg/L		0.280	0.180		0.11
Endrin	ug/L	0.2	<0.54	<0.04	<0.04	<0.04
Lindane	ug/L	4	<0.17	<1	<1	<1
Methoxychlor	ug/L	100	<2.5	<20	<20	<20
Toxaphene	ug/L	5	<6.0	<1	<1	<1
24D	ug/L	100	<0.31	<20	<20	<20
245TP	ug/L	10	<0.14	<2	<2	<2

Table F-15. Results of Monitoring Well Analyses for M-Area
(continued)^a

MSB-6		Downgradient	N101105.06 N101080.1	E46328.28 E46462.6	Elev = 336.1 (83) Elev = 339.7 (82)	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		237.0	237.2	231.8	228.1
Coliform B	#/100 ml		0	0	>16	33
Color	CU	15	10	5	15	5
Corrosion			No	No	No	No
Odor		3	17	17	16	8
pH	pH	6.5-8.5	5.3	6.0	5.2	4.3
Specific Conductivity	µmho/cm		88	146	71	35
TDS	mg/L	500	76	100	64	30
Temp	°C		18.9	20.7	16.6	16.4
Turbidity	1/TU		2.5	7.5	3.5	0.6
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	0.104	0.19	0.24	0.47
Be	mg/L		<0.010	<0.010	<0.005	<0.005
Cd	mg/L	0.01	0.004	0.007	0.001	0.016
Cr	mg/L	0.05	0.005	0.017	0.014	0.016
Cu	mg/L	1.0	0.014	0.043	0.013	0.008
Fe	mg/L	0.3	5.89	16.93	13.98	18.79
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	0.483	0.836	0.42	0.34
Na	mg/L		25.96	37.56	12.92	6.93
Ni	mg/L		0.011	0.014	0.046	0.031
Pb	mg/L	0.05	0.042	0.085	0.030	0.013
Se	mg/L	0.01	<0.002	0.002	<0.002	<0.002
Zn	mg/L	5	2.595	14.87	0.196	0.152
Cl	mg/L	250	4	4.7	5.2	4.4
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	<0.10	<0.18	<0.10	0.06
Foaming agents	mg/L	0.5	0.02	0.30	0.02	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	0.33	0.23	0.46	0.61
SO ₄	mg/L	250	<5	<5	<5	<5
Gross Alpha	pCi/L	15	0.8±0.6	1.6±0.8	1.4±0.8	1.8
Gross Beta	pCi/L		4±8	15.3±8.6	2.1±8.0	4.8
Ra	pCi/L	5	0.57	0.88		0.27
DOC	mg/L		6	6	5	7.5
GC	µg/L		110	<40	<40	<40
Phenols	mg/L			<0.002	0.002	<0.002
TOC	mg/L		2	3	16	15.3
TOR	mg/L		0.530	0.250	0.37	0.008
Endrin	µg/L	0.2	<0.54	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.17	<1	<1	<1
Methoxychlor	µg/L	100	<2.5	<20	<20	<20
Toxaphene	µg/L	5	<6.0	<1	<1	<1
24D	µg/L	100	<0.31	<20	<20	<20
245TP	µg/L	10	<0.14	<2	<2	<2

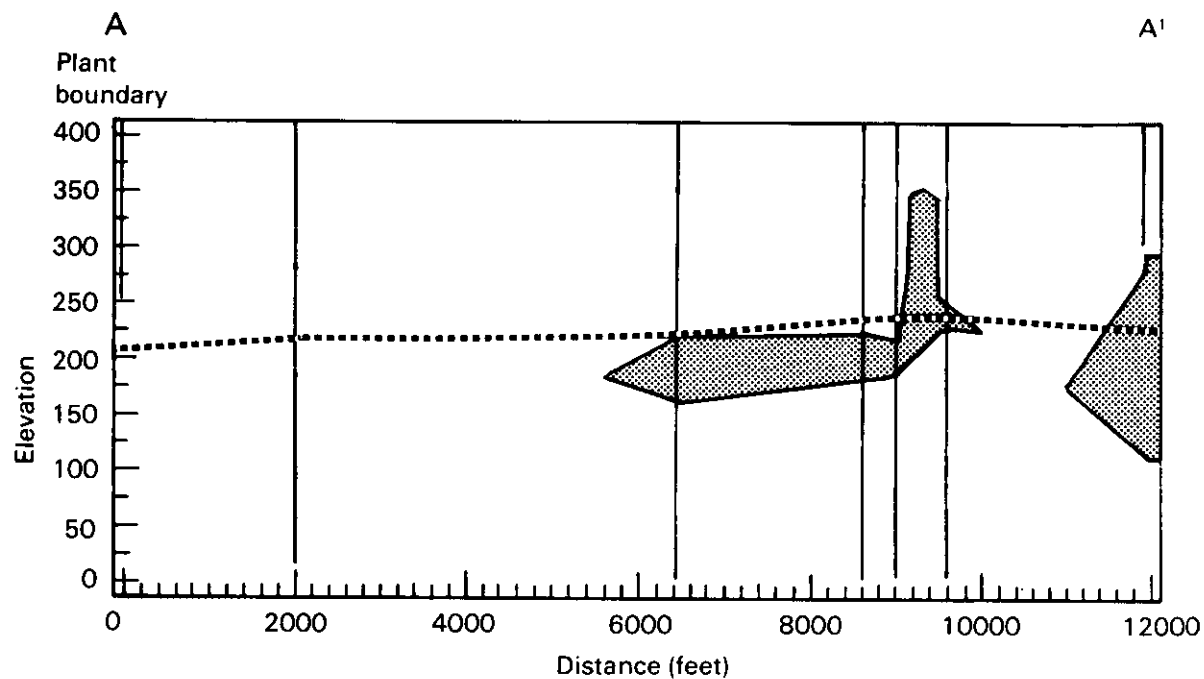
Table F-15. Results of monitoring well analyses for M-Area
(continued)^a

MSB-7		Downgradient	N100563.73 N100730.7	E46737.06 E46785.9	Elev = 343.93 (83) Elev = 340.7 (82)	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		238.7	239.2	234.3	237.4
Coliform B	#/100 ml		0	0	>16	79
Color	CU	15	5	3	15	2
Corrosion			No	No	No	No
Odor		3	2	2	16	4
pH	pH	6.5-8.5	5.4	5.9	5.4	4.5
Specific Conductivity	µmho/cm		166	136	89	47
TDS	mg/L	500	117	94	95	36
Temp	°C		18.6	19.9	16.7	16.4
Turbidity	1/TU		2.2	1.7	6.2	0.5
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.050	<0.05	0.26	0.46
Be	mg/L		<0.010	<0.010	<0.007	<0.005
Cd	mg/L	0.01	0.007	0.016	0.002	0.025
Cr	mg/L	0.05	0.025	0.017	0.046	0.040
Cu	mg/L	1.0	0.001	0.014	0.010	0.009
Fe	mg/L	0.3	6.240	21.20	62.98	48.14
Hg	mg/L	0.002	<0.0002	<0.0002	0.0003	<0.0002
Mn	mg/L	0.05	0.620	0.963	0.31	0.17
Na	mg/L		8.14	4.02	12.48	5.45
Ni	mg/L		1.051	0.937	0.024	0.023
Pb	mg/L	0.05	0.143	0.031	0.025	0.020
Se	mg/L	0.01	<0.002	0.002	<0.002	<0.002
Zn	mg/L	5	2.110	1.964	0.173	0.121
Cl	mg/L	250	4	6.7	3.8	2.6
CN	mg/L		<0.005	<0.005	<0.005	<0.005
F	mg/L	1.6	0.16	0.36	<0.10	<0.01
Foaming agents	mg/L	0.5	0.07	<0.01	0.02	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	0.04	0.06	1.01	1.11
SO ₄	mg/L	250	<5	10	<5	<5
Gross Alpha	pCi/L	15	0.7±0.6	1.2±0.7	5.9±1.4	3.0
Gross Beta	pCi/L		12±9	11.3±8.6	9.9±8.3	10.0
Ra	pCi/L	5	0.79	0.83		0.78
DOC	mg/L		6	6	5	7.5
GC	µg/L		<40	<40	<40	<40
Phenols	mg/L		<0.002	<0.002	0.002	<0.002
TOC	mg/L		2	9	28	26.0
TOH	mg/L		0.079	0.210	0.39	0.031
Endrin	µg/L	0.2	<0.54	<0.04	<0.04	<0.04
Lindane	µg/L	4	<0.17	<1	<1	<1
Methoxychlor	µg/L	100	<2.5	<20	<20	<20
Toxaphene	µg/L	5	<6.0	<1	<1	<1
24D	µg/L	100	<0.31	<20	<20	<20
245TP	µg/L	10	<0.14	<2	<2	<2

Table F-15. Results of monitoring well analyses for M-Area
(continued)^a

MSB-8		Downgradient	N100796.20 N100944.0	E47302.80 E47145.4	Elev = 343.72 (83) Elev = 339.4 (82)	
Parameter	Units	DWS	2QR 82	3QR 82	4QR 82	1QR 83
Water Table Elevation	Ft		241.4	240.9	236.8	241.2
Coliform B	#/100 ml		0	0	>16	120
Color	CU	15	30	5	15	2
Corrosion			No	No	No	No
Odor		3	2	0	16	4
pH	pH	6.5-8.5	5.6	6.0	5.4	4.9
Specific Conductivity	umho/cm		195	194	82	31
TDS	mg/L	500	141	151	116	39
Temp	°C		17.7	18.8	16.9	15.4
Turbidity	1/TU		31	59	5.1	0.4
Ag	mg/L	0.05	<0.001	<0.001	<0.001	<0.001
As	mg/L	0.05	<0.002	<0.002	<0.002	<0.002
Ba	mg/L	1.0	<0.050	<0.05	0.12	0.70
Be	mg/L		<0.010	0.052	<0.005	0.006
Cd	mg/L	0.01	0.010	<0.001	<0.001	0.005
Cr	mg/L	0.05	0.001	0.010	0.040	0.046
Cu	mg/L	1.0	0.005	0.030	0.012	0.038
Fe	mg/L	0.3	7.925	9.05	90.8	299.4
Hg	mg/L	0.002	<0.0002	<0.0002	0.0007	0.0002
Mn	mg/L	0.05	0.226	0.262	0.32	0.54
Na	mg/L		27.76	24.48	14.92	5.06
Ni	mg/L		0.412	0.391	0.052	0.036
Pb	mg/L	0.05	0.101	0.043	0.007	0.024
Se	mg/L	0.01	<0.002	0.002	<0.002	<0.002
Zn	mg/L	5	0.742	0.072	0.071	0.208
Cl	mg/L	250	6	9.5	2.5	1.3
CN	mg/L		<0.005	<0.005	<0.009	<0.005
F	mg/L	1.6	0.10	0.20	<0.10	0.01
Foaming agents	mg/L	0.5	0.03	<0.01	<0.01	<0.01
H ₂ S	mg/L		<1.0	<1.0	<1.0	<1.0
NO ₃	mg/L	10	7.00	10.39	4.39	2.11
SO ₄	mg/L	250	<5	<5	<5	<5
Gross Alpha	pCi/L	15	2.4±1	3.5±1.1	5.6±1.4	13.9
Gross Beta	pCi/L		6±8	18.2±8.7	9.3±7.8	14.3
Ra	pCi/L	5	0.23	1.14		0.68
DOC	mg/L		5	14	4	4.2
GC	ug/L		<40	<40	<40	43
Phenols	mg/L		0.004	<0.002	0.002	<0.002
TOC	mg/L		6	11	24	31.5
TOH	mg/L		0.074	0.270	0.48	0.20
Endrin	ug/L	0.2	<0.54	<0.04	<0.04	<0.04
Lindane	ug/L	4	<0.17	<1	<1	<1
Methoxychlor	ug/L	100	<2.5	<20	<20	<20
Toxaphene	ug/L	5	<6.0	<1	<1	<1
24D	ug/L	100	<0.31	<20	<20	<20
245TP	ug/L	10	<0.14	<2	<2	<2

^aAdapted from Du Pont, 1983



Legend:

 Trichloroethylene and perchloroethylene above detectability between 1 and 10 µg/kg.

----- Water table (1982)

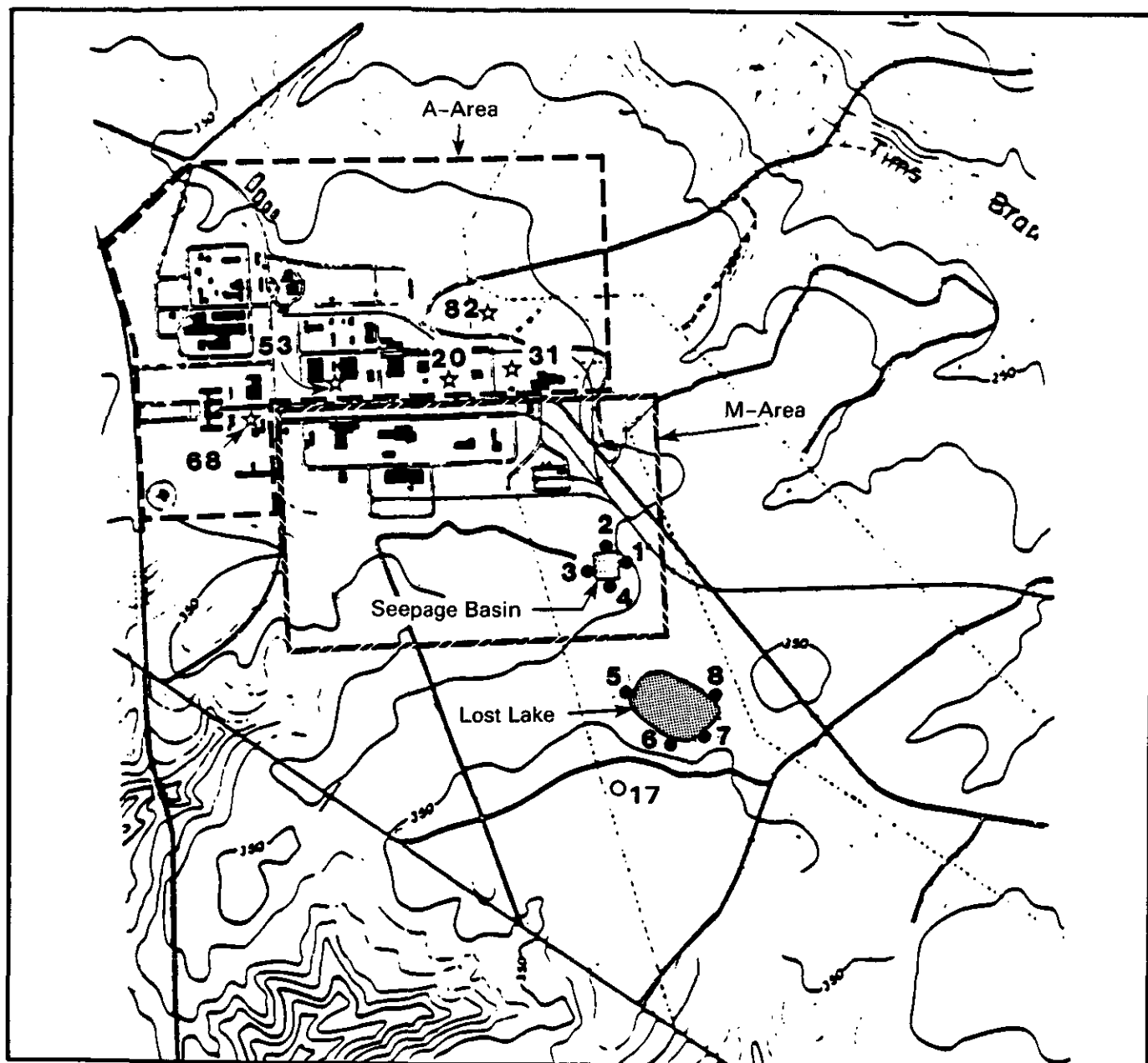
Note: 1.0 foot = 0.3048 meter.

Figure F-37 shows the location of cross section AA'.

Source: Du Pont (1983).

Figure F-36. M-Area plumes of trichloroethylene and perchloroethylene from soil samples.

EN-51



Legend:

- Monitoring Well
See Table F-15 for monitoring results.
- See Figure F-11 for location of well cluster section.
- ☆ A-Area production wells
A-A' Location of cross-section shown in Figure F-36.

0 500 1000 meters



Figure F-37. Location of MSB (M-Area) hazardous-waste monitoring wells and A-Area production wells.

annual concentrations range up to 3300 microcuries per liter, but are typically less than 100 microcuries per liter. Traces of alpha and beta-gamma emitters have moved only short distances (up to a few hundred meters) from the point of entry.

F.6 SRP GROUND-WATER PROTECTION PLAN

The Department of Energy is committed to the protection of ground-water quality at SRP. Specifically, DOE is committed to (1) an expanded program of site-wide ground-water monitoring and study; (2) the continued involvement of the State of South Carolina in ground-water monitoring activities at and in the vicinity of SRP; and (3) taking mitigative actions at SRP to reduce pollutants released to the ground water and to establish with the State of South Carolina a mutually agreed-on compliance schedule for these actions. Current plans call for discontinuing the use of the M-Area seepage basin by April 1985 and constructing a process wastewater-treatment facility for M-Area liquid effluents (see Section 5.1.1.2). These commitments have been formalized by the Memorandum of Understanding between DOE and the State of South Carolina (Congressional Record, July 14, 1983, p. S1000) and by the FY 1984 Supplemental Appropriations Bill (Public Law 98-191, signed November 30, 1983).

A draft "SRP Groundwater Protection Implementation Plan" was developed recently (September 1983) to examine strategies and schedules to implement mitigative actions required to protect the quality of the ground waters beneath SRP. In addition to the commitment for M-Area, this sitewide plan considers other remedial actions, including discontinuing the use of seepage basins in F- and H-Areas and the continued use of the present SRP Burial Ground. It has been reviewed by the State of South Carolina and the U.S. Environmental Protection Agency--Region IV; responses to review comments are being prepared. Implementation of mitigative actions would be accomplished under DOE's Hazardous Waste and Radioactive Mixed Waste Management Program, which is comparable to the design and performance criteria, other technical requirements, and recordkeeping and reporting requirements of the regulations (40 CFR 260-266 and 270) that EPA has adopted to implement RCRA (42 USC 6901 et seq.) (Memorandum of Understanding between DOE and EPA dated February 22, 1984). These mitigative actions would also be compatible with the State of South Carolina's hazardous waste management regulations. The draft "SRP Groundwater Protection Implementation Plan" has been incorporated in the "SR RCRA Program Management Plan" of January 23, 1984, approved by G. K. Oertel, Acting Manager. Chapter 7 contains additional information on RCRA.

The sitewide ground-water protection plan described above will be the subject of a separate NEPA review. Topics to be discussed in this review will include the sitewide use of seepage basins, disposal pits and the burial ground; mitigation and remedial measures; decommissioning of currently operating facilities receiving hazardous and radioactive mixed wastes; occupational and offsite exposures; and effects of research and development activities.

A two-volume technical document (Du Pont, 1983) supports the draft "SRP Groundwater Protection Implementation Plan." Volume I covers the site geohydrology and solid/hazardous waste; Volume II is concerned with radioactive

waste at SRP. In addition, the "SRP Groundwater Protection Policy" has been approved by G. K. Oertel, Acting Manager (January 23, 1984). This policy states that:

It is the goal of this Operations Office that all operations conducted at the SRP will not adversely affect the quality of any of the ground-water resources.

- An extensive monitoring program, including sampling for both indicator and specific parameters, shall be conducted on a continuing basis.
- All new facilities shall be designed utilizing groundwater protection concepts; new seepage basin facilities shall not be constructed.
- All waste disposal sites on the SRP shall be fully assessed for their impacts on groundwater, utilizing an integrated, interdisciplinary approach.
- Site utilization of groundwater resources shall be reviewed to assure compatibility with regional needs.
- Appropriate government requirements and agencies shall be consulted where improvements in groundwater quality are desirable.
- Mitigative actions shall be taken, where necessary, in a timely manner to protect groundwater quality.

This Operations Office will continue to cooperate with other Federal and State agencies on matters concerning groundwater protection and utilization.

In compliance with this policy, an SRP baseline hydrogeologic investigation program plan and a ground-water modeling program plan have been formulated (Bledsoe, 1984; Stephenson, 1984). Under this plan, 17 clusters of six to eight wells each will be drilled at strategic SRP locations to further define the hydrostratigraphic units and their geohydraulic properties. The wells will provide additional data on ground-water levels and quality for each of the major Coastal Plain hydrostratigraphic units on a sitewide basis. Information obtained from this network and from other monitoring wells will be used in computer modeling of the SRP ground-water regime.

Two other projects have been initiated recently to protect SRP ground waters. One is the design and construction of a wastewater-treatment plant to process the liquid effluent presently being discharged to the M-Area seepage basin. Treated wastewater from this plant will be discharged to an onsite stream under an NPDES permit. Current plans call for the completion of this facility by April 1985, about 6 months before the date required by the FY 1984 Supplemental Appropriations Bill (Public Law 98-181, signed November 30, 1983).

The high concentrations of chlorinated hydrocarbons found in the A- and M-Area shallow ground-water system (Tertiary ground-water system) are being removed by both a pilot and a prototype air stripper units, with capacities of

0.075 and 0.18 cubic meter per minute, respectively. Project S-2583 (Steele, 1983) will establish a 1.5-cubic-meter-per-minute production interceptor/recovery well-air stripper system in A- and M-Areas. This system, scheduled to start operating in August 1984, has been designed to prevent chlorinated hydrocarbon contaminants in the shallow (Tertiary) M-Area ground-water system from reaching the drinking water of any offsite well or the Tuscaloosa Aquifer. Specifically, it will consist of nine 200-foot-deep interceptor/recovery (I/R) wells and an air stripper capable of removing about 30 tons of chlorinated hydrocarbons per year during the first few years of operation; thereafter, the removal rate will decrease as the concentrations of contaminants decrease. Liquid effluent from the air stripping column will either be routed to the A-Area powerhouse process-water system or used as non-process cooling water in M-Area; in either case, the wastewater would be discharged through an NPDES-permitted outfall. This I/R-well-and-air-stripping system will be constructed and operated under permits issued by the State of South Carolina. Both the EPA and SCDHEC have reviewed the initial project plans, and have agreed that the planned program is technically sound.

DOE is planning an effluent-treatment facility to treat the wastewaters that are currently discharged to the E- and H-Area seepage basins, so they can be released to an NPDES-permitted outfall. The Department of Energy will submit for approval to Congress a Fiscal Year 1986 funding request for this treatment facility; operation is scheduled for October 1988. DOE also plans to install additional monitoring wells and to take cores within the basins to provide basic data for decommissioning plans. Currently, the basins are scheduled for decommissioning by the end of 1990.

DA-2

Section 4.4.3 identifies the periodic disposal of radioactively contaminated water to the L-Area seepage basin as DOE's preferred alternative for the disposal of disassembly-basin purge water. The Department will continue, however, to study and evaluate the practicability of moderator detritiation. Contingent on feasibility and approval of Congressional funding, the moderator detritiation concept will be implemented. As part of a separate NEPA review of the SRP Groundwater Protection Implementation Plan, the Department will evaluate alternative cleanup and remedial-action measures for the L-Area seepage basin.

F.7 WELL DATA FILE

In December 1983, the computerized Well Data File (WDF) at SRP contained records for 6404 wells and borings. Most of these wells are sealed and abandoned. The WDF provides a central source of information on well and boring construction, geology, and water quality. As many as 66 variables can be entered for each well. There are currently 620 monitoring wells and 70 production wells, in the WDF. The remainder are engineering and test borings, grout wells, and miscellaneous wells; this last category includes about 600 old wells, the exact location and status of which are unknown (locations are known within 100 meters).

EL-25

Based on pre-SRP well-drilling practices, many of these old wells are believed to have been shallow hand-dug domestic wells. Some probably penetrated the Tuscaloosa, including some drilled flowing wells discovered on SRP in the

Savannah River valley. Any open holes, rusted-out casings, or otherwise defective wells can provide a direct route for contaminated surface water or shallow ground water to contaminate deeper aquifers, even the Tuscaloosa. Contamination of lower aquifers cannot occur from flowing wells. No hand-dug or abandoned wells are known to exist at or adjacent to either L-Reactor or any waste disposal sites of its support facilities. In addition, no contamination of the Tuscaloosa aquifer by radionuclides and chlorinated hydrocarbons has been noted in the central portion of the SRP. Abandoned well S329 in the Steel Creek floodplain, which is reported to be 20 centimeters in diameter and 33 meters deep, could be flooded if a cooling lake is selected as the alternative cooling-water system (see Section 4.4.2). This well is believed to have drawn from the calcareous zone in the McBean Formation. Additional information on abandoned wells is contained in Appendix L.

EL-25 Contamination of well water by chlorinated hydrocarbons (used as degreasers in M-Area) from A-Area wells producing from the Tuscaloosa was confirmed earlier in 1983. This contamination now appears to have resulted from chlorinated hydrocarbons that entered the well annuli from the contaminated shallow (Tertiary) aquifer in A- and M-Areas, and not from any generalized contamination of the Tuscaloosa aquifer itself (Geraghty and Miller, 1983).

Geophysical surveys of well 53A, which exhibited the highest contamination, indicated there were no gross casing breaks. However, packer tests indicated that the casing might leak, and a cement bond log showed that there were extensive areas where the cement sheath around the casings was not bound to the casing. Such areas of poor bond would provide avenues for contaminated water from the Tertiary to migrate directly to screened sections of the Tuscaloosa aquifer. Additional details are provided in Geraghty and Miller (1983).

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APPENDIX G

ENVIRONMENTAL IMPACT OF POSTULATED PLANT ACCIDENTS

This appendix provides supplementary information for Section 4.2.1, Reactor Accidents. This appendix describes (1) the general characteristics of accidents; (2) the actual experience with SRP reactor incidents; (3) safety features of the L-Reactor and of the site that act to mitigate the consequences of accidents; (4) all postulated transients considered for the safety evaluation of L-Reactor; (5) radiological consequences of four hypothetical accidents that cover a spectrum of significant events postulated to release radioactivity above normal operating limits; and (6) input considerations for a CRAC2 analysis of a hypothetical 10-percent core-melt accident (Section 4.2.1.5).

G.1 GENERAL CHARACTERISTICS OF ACCIDENTS

The term "accident," as used in this section, refers to any postulated event that could result in a release of radioactive materials into the environment. The predominant focus is on events that can lead to releases substantially in excess of permissible limits for normal operation.

Several features combine to reduce the risk associated with accidents at nuclear plants. Safety features in the design, construction, and operation, comprising the first line of defense, are devoted to the prevention of the release of radioactive materials from their normal places of confinement within the plant. Also, a number of additional lines of defense are designed to mitigate the consequences of failures in the first line. The most important mitigative features for L-Reactor are described in Section G.3.1. Detailed descriptions of these features may be found in the Safety Analysis Report (SAR) (Du Pont, 1983).

The L-Reactor is designed to produce plutonium by the absorption of neutrons in uranium. The reactor uses heavy water (D_2O) as a moderator and as the primary coolant to remove heat generated by the nuclear fission process. L-Reactor operates at significantly lower temperatures and pressures than light-water commercial nuclear power plants designed for electric power generation. This feature in itself tends to reduce the consequences of many types of accidents. In addition, the absence of a turbine load eliminates a whole range of accidents possible with conventional nuclear power plants.

The transients considered for evaluation of L-Reactor safety are listed in Table G-1. The reactor will operate at a power limit that is determined separately for each charge and each fuel and target cycle so that for any anticipated transient, operation at or below the operating limit would prevent release of radioactivity to the environment. Major safety systems, listed in Table G-2, have been incorporated into the design and operation of the reactor to shut down the reactor and limit the release of radioactivity if necessary.

Four hypothetical accidents are evaluated that cover a spectrum of events postulated to release radioactivity. These four hypothetical accidents, which

Table G-1. Postulated accidents

No.	Accident description	Condition of reactor	Has initiating event occurred at SRP	Main effect
REACTIVITY ADDITION ACCIDENTS				
1	Single rod withdrawal	Full power	Yes	Local power increase
2	Partial rod insertion	Full power	Yes	Local power increase
3a	Gang rod withdrawal	Full power	No	Reactor power increase
3b	Gang rod withdrawal	Low power	No	Rapid power rise
4	Control rod melting	Full power	No	Local power increase
5	Target melting	Full power	No	Local power increase
6	Fuel melting	Full power	No	Fission products in moderator
7	Reloading error	Shutdown-charge-discharge	No	Inadvertent criticality
FLOW REDUCTION ACCIDENTS				
8	Loss of D ₂ O coolant pump power	Full power	No	Increased assembly temperature
9	Loss of H ₂ O pump power	Full power	No	Increased assembly temperature
10	Loss of both D ₂ O and H ₂ O pump power	Full power	No	Increased assembly temperature
11	Pump shaft break	Full power	No	Increased assembly temperature
12	Rotovalve closure	Full power	Yes ^a	Increased assembly temperature
13	Flow reduction in single assembly	Full power	Yes	Increased assembly temperature
14	Loss of control-rod cooling	Full power	Yes	Increased control rod temperature
15	Loss of blanket-gas pressure	Full power	No ^b	Decreased saturation temperature
16	Loss of coolant (leak)	Full power	No	Decreased moderator level; increased temperature; release of radioactivity
17	Loss of D ₂ O circulation	Full power	No	Increased assembly temperature
18	Loss of cooling during or after discharge	Discharge operations	No	Possible melting of fuel

^aTwo rotovalves closed in one system only one time; closure of all rotovalves in two systems has not occurred.

^bSlow leaks of blanket gas have occurred.

Table G-2. Major safety systems

Reactor shutdown and safety systems	Engineered safety systems
1. Safety rods	1. Emergency cooling system (ECS)
2. Control rods	2. Water removal and storage
3. Scram instruments and alarms	3. Activity confinement system
4. Supplementary safety systems (SSS)	4. Confinement heat removal system
5. Automatic backup shutdown--safety computer (ABS-S/C)	5. Reactor room spray system
6. Automatic backup shutdown--gang temperature monitor (ABS-GTM)	6. Discharge assembly cooling

have never occurred at SRP, include (1) a total moderator spill, (2) a discharge mishap in which an irradiated assembly is dropped and melts; (3) a misloading accident during charge-discharge operations resulting in melting less than 3 percent of the reactor core; and (4) a loss-of-coolant accident resulting in the melting of 1 percent of the reactor core. No credible accident sequences have been identified that will cause a reactor accident resulting in core damage greater than 3 percent. |FG-3

The probabilities reported in this document are based on more than 115 reactor-years of operating experience at Savannah River Plant, conservative engineering judgment, and failure modes and effects analyses (Church, 1983). The probabilistic and risk assessment discussion contained in this document has been based in part on the methodology presented in the Reactor Safety Study (NRC, 1975). In addition, a probabilistic risk assessment (PRA) of the SRP reactors is being performed.

No accidents occurred during the previous operation of the L-Reactor that resulted in the release of radioactivity to the public above DOE standards for normal operations. Safety-system improvements made to other SRP reactors, as a result of years of operating experience, have reduced the probability of an accident. These improvements have also been made on the L-Reactor.

G.2 ACCIDENT EXPERIENCE AND OBSERVED IMPACTS

This section describes the actual experience with SRP reactors. No significant reactor accidents have occurred at the SRP in its 30 years of operation. The following sections describe reactivity addition, flow reduction, and other

events that might have led to substantial release of radioactive material if the safety systems or automatic backup systems had failed to function properly.

G.2.1 Reactivity addition

G.2.1.1 Single control-rod withdrawal

TC | An average of two to three unwanted control-rod movements (Jones, 1972) has occurred per reactor year since 1954, and half of the movements were withdrawals that resulted in the addition of reactivity. The incidents were caused by either personnel errors or control-rod drive system malfunctions. However, these events never caused damage to the fuel or release of radioactivity into the environment, because an unwanted rod motion was usually stopped and rod position corrected immediately after the unwanted movement was recognized. Only about 1 percent of these events persisted long enough to actuate the control-rod reversal system. Safety rod scram action has never been required for inadvertent control-rod action.

G.2.1.2 Partial control-rod insertion

Approximately half of the two to three control-rod movements that have occurred per reactor year since 1954 were applicable to partial control rods. Fewer than half of these unwanted partial control-rod movements were insertions that resulted in an addition of reactivity. However, these events never caused damage to the fuel or any release of radioactivity to the environment.

G.2.1.3 Gang-rod withdrawal at full power

No unwanted continuous gang-rod withdrawal has occurred at SRP. There were cases when the control computer attempted to raise power because of an erroneous input signal (Jones, 1972). Such incidents occurred at the rate of about 0.34 per reactor year. In one such incident in 1976, a spurious signal withdrew Gang I rods 0.2 foot in 15 seconds. The withdrawal by the control computer is not continuous and is terminated when the temperature signal reaches the operating limit. In all of these incidents, no damage to the fuel and no radioactivity release has occurred.

G.2.1.4 Gang-rod withdrawal at low power

TC | No unwanted continuous gang-rod withdrawal has occurred during low-power operation at the Savannah River Plant.

G.2.1.5 Control-rod melting

No control-rod melting has ever occurred at SRP. There have been several cases where the control-rod housing was not seated which reduced the cooling of the rods (Du Pont, 1983), but no rods were damaged.

G.2.1.6 Fuel assembly melting

Fuel melting has never occurred in the SRP reactors. During irradiation of the Californium-I high-flux charge in 1969 and early 1970, several fuel assemblies experienced cladding failures that resulted in releases of activity to the moderator (Du Pont, 1983). An estimated 40,000 curies of fission products entered the moderator and were subsequently removed by the moderator purification system. The failures were caused by improper allowance for assembly rib effects in heat transfer calculations. A small amount of noble gases was released into the blanket gas and subsequently discharged to the atmosphere. The release created no undue safety hazard. Noble gas monitors were installed in each operating reactor in 1972; any releases would now be recorded.

G.2.1.7 Target-assembly melting

No target-assembly has melted at SRP. While reductions in assembly coolant flow have been observed, all such reductions have been slow enough to enable shutting down the reactor without melting the assembly.

G.2.1.8 Fuel-reloading error

No reloading errors have occurred that have caused significant approach to criticality. One misloaded assembly was detected and corrected before reactor operations began.

G.2.2 Flow reduction

G.2.2.1 Loss of D₂O coolant pumps

The abrupt and total loss of offsite (commercial) a.c. power has occurred only four times in the history of Savannah River Plant, the longest being 38 minutes in duration. There are 11 onsite generators that normally supply about half of the electrical power to the 115-kilovolt grid. The complete loss of all 11 onsite generators has never occurred. Loss of a.c. power to the D₂O pump motors has been experienced at Savannah River Plant (Du Pont, 1983). The protective systems, including the independent backup d.c. motors, prevented any potentially damaging accidents.

A project currently underway will provide automatic load shedding following a loss of offsite power. This will prevent the resultant loss of the onsite

generators so that power will continue to be supplied to the 115-kilovolt grid and to associated vital equipment.

G.2.2.2 Loss of H₂O pumps

Loss of all a.c. power to the H₂O pump motors has never been experienced at Savannah River Plant (Du Pont, 1983); however, a partial loss has occurred. The protective systems, including gravity flow backup cooling, prevented potentially damaging effects.

G.2.2.3 Pump shaft break

A drive shaft break between the D₂O pump impeller and the flywheel has never occurred at SRP. D₂O pump shafts are inspected during periodic overhaul of the pumps.

G.2.2.4 Rotovalve closure

Rotovalves are installed in the six external loops of D₂O circulation system between each of the 12 heat exchangers and the reactor plenum. Spontaneous closure of rotovalves has occurred on several occasions (Du Pont, 1983). On one occasion both rotovalves in a single system closed simultaneously at full power. However, a closure involving more than one external loop has not occurred, nor has any significant loss of D₂O circulation occurred due to rotovalve closures. No core damage or release of radioactive material occurred in any of the above incidents.

G.2.2.5 Flow reduction in a single assembly

The gradual reduction in flow could occur to a single coolant channel of a fuel or target assembly caused by cladding failure. Such failures accompanied by flow reduction have occurred at Savannah River Plant: five target failures in the last 3 years of operation of three reactors. The protective system was adequate to mitigate the consequences of this accident and prevent fuel melting and the release of radioactivity.

G.2.2.6 Loss of control-rod cooling

Control-rod cooling is accomplished by D₂O upflow through the septifoil (control-rod housing) from a header supplied by lines from the heat exchangers. The header pressure (and therefore flow) decreased on rare occasions, and the header pressure scram circuit operated properly to shut down the reactor. There were two cases of septifoils being unseated for long periods of time resulting

in boiling of the coolant in the septifoils (Du Pont, 1983). Even then the control rods were not damaged and no radioactivity was released.

G.2.2.7 Loss of blanket gas pressure

Slow leaks of blanket gas have occurred without damage to the reactor or release of radioactivity. No rapid drop in blanket gas pressure has ever occurred.

G.2.2.8 Loss-of-coolant accident

No loss-of-coolant accident (LOCA) has ever occurred at Savannah River Plant. Furthermore, no fuel melting is anticipated in any credible LOCA. Small leaks from seals, flanges, and valves occasionally occur. The D₂O makeup system can replace D₂O at rates up to 15 liters per minute, and it is planned to increase these capabilities to 75 liters per minute. Most of the leak rates experienced at Savannah River Plant have been less than 2 liters per minute and only two leaks have approached 75 liters per minute (Joseph et al., 1970; Nomm, 1983).

G.2.2.9 Loss of D₂O circulation

Loss of a.c. power to the D₂O pump motors has occurred in the past (Du Pont, 1983). A complete loss of D₂O circulation has never occurred due to the backup d.c. motors operated by the independent diesel generator for each system.

G.2.2.10 Loss of cooling during and after assembly discharge

The discharge machine cooling systems have always worked when required. In about 300,000 assembly discharge operations, there have been instances in which the discharge operation was interrupted and emergency cooling was required. No fission products have been released because of failure of the cooling system during assembly discharge operations. In 1969, 100,000 curies of antimony and tellurium isotopes were released to the reactor building of which 0.003 curies were released to the environment, when an antimony-beryllium source rod melted while being held in air (Olliff, 1970; Brown, 1971; AEC, 1973). This accident was the result of administrative error; appropriate procedural controls have been implemented. This was the only time that the confinement system was required to function at SRP. No irradiated assembly has been dropped at SRP during discharge operations.

G.2.3 D₂O moderator spill

A sizable spillage of D₂O moderator occurred once during the early stages of operation. In July 1954, over a 12-hour period, an estimated 45,000 liters |TC

TC| of D₂O moderator overflowed seal leakage collection pots in the motor room in L-Area because two valves inadvertently were left open. An estimated 38,000 liters were recovered from sumps in the building. The moderator lost contained insignificant amounts of tritium because the reactor had achieved initial criticality only 15 days before the spill. In more recent history, spills of 380 to 3800 liters have occurred at a rate of about once per year.

G.2.4 Summary

The evidence of accident frequency is a useful indicator of future probabilities. As shown in the preceding sections, there have been no significant reactor accidents at SRP.

G.3 MITIGATION OF ACCIDENT SEQUENCES

A summary of safety features of the L-Reactor and of the SRP site that act to mitigate the consequences of accidents are provided in the following subsections.

G.3.1 Design features

L-Reactor is essentially identical to the other SRP reactors currently in operation. Each unit contains features designed to prevent accidental release of fission products from the fuel and targets and to lessen the consequences should such a release occur. These accident-preventive and mitigative features are referred to as shutdown systems, engineered safety systems, support systems, and a unique reactor power limit system. To establish design and operating specifications for L-Reactor, postulated events referred to as anticipated transients and accidents are analyzed.

CU-3 | Ward et al. (1980) studied the effects of neutron irradiation on the stainless-steel SRP reactor vessels and concluded that the vessels have experienced no significant deleterious effects. Furthermore, no deleterious metallurgical effects are expected in the future because neutron fluence has been accumulating very slowly since operations with lithium-blanketed charges began in 1968. At the temperatures and neutron fluences experienced by SRP reactors, yield strength and tensile strength increase; ductility and impact strength decline with increasing neutron fluence. The temperature of the SRP reactor tank walls is too low for significant swelling to occur from voids or gas bubbles resulting from neutron irradiation. In addition, experimental evidence has demonstrated that a relaxation of preirradiation stresses also results from fast neutron fluence. The reactor tanks are not expected to be affected by fatigue damage because the stresses encountered in the low-temperature, low-pressure system are well below endurance limits, and vibration from process-water circulation has been reduced to a low level.

G.3.1.1 Limit system

L-Reactor will operate at limits which are determined by a number of accident analyses for each reactor charge. These limits define the conditions at which the reactor can operate and still allow the protective instrument system to terminate any anticipated transient without exceeding prescribed damage criteria (for example, an approach to fuel melting). Three such limits are established, and the reactor is operated at the lowest of them.

1. The first limit is defined by assuming that the safety-rod scram--the primary emergency shutdown system--works on demand. This is the "transient protection" limit.
2. The second limit is defined by assuming that the safety-rod system fails and that an automatic backup system (called the automatic backup shutdown--safety computer, or ABS-S/C) is required to terminate the transient. This second limit defines the confinement protection limit, which is based on the criterion that the airborne activity confinement system not be damaged.
3. The third limit, the emergency cooling system (ECS) limit, is established by assuming a minimal level of emergency cooling system operability.

In principle, any of the three limits could be most restrictive; however, in practice and by design, the transient protection limit is usually the most restrictive. A more complete description of the SRP Limit System is given in the SAR.

Each plutonium-producing reactor charge is moderated and cooled by D_2O and has the same spacing between fuel and target assemblies. But changes in moderator and coolant temperature coefficients during the charge exposure time and changes in the average and relative fissile content of the fuel assemblies, among others, require that an accident analysis be made for each charge. Some of the analyses can be generic in nature (such as confinement protection limits), but the more important analyses, which generally fix the operating limits for the charge, are charge-specific. A summary of the analyses required for a charge is given in Table G-3.

The range of operating variables experienced during the 30 years of reactor operation at Savannah River Plant are given in Table G-4. The large ranges shown here demonstrate the flexibility available in a charge design. L-Reactor is currently scheduled to operate with a mixed-lattice, plutonium-producing charge, as shown in Table G-5.

G.3.1.2 Reactor shutdown systems

Several redundant systems operate to rapidly shut down the reactor, if necessary. The primary reactor shutdown mechanism is safety and control rod insertion, activated by the scram instruments or manually; the secondary shutdown

Table G-3. Summary of data and analyses
for each reactor charge

Data and analysis	Analysis required
Technical limits and transient-protection limits for assembly effluent temperature	Yes
Technical limits and transient-protection limits for film-boiling burnout risk	Yes
Technical limits and transient-protection limits for reactor effluent temperature	Yes
Confinement protection limits for accidents with assumed inoperative safety rods	Yes
Criticality during withdrawal of safety rods	Yes
Shutdown system worths	Yes
Primary and secondary scram circuit designation	Yes
Natural convection cooling	Yes
Mechanical and metallurgical properties during discharge	Yes
Protection against criticality during charge-discharge operations	Yes
Storage and handling of enriched uranium assemblies	Yes
Shield heat loads	Yes
Emergency cooling of irradiated fuel	Yes
Heat removal from safety and control rods	Yes
Temperature and void coefficients	Yes
Startup accident analysis	Yes
Xenon oscillations	Yes
Compliance with Technical Standards and safety analyses	Yes

system is the supplementary safety system (injection of gadolinium nitrate), activated automatically by the gang temperature monitor and the safety computers, or manually.

Safety rods

The safety rods provide a primary rapid-shutdown mechanism for the reactor and thus prevent core damage. Upon receipt of a scram signal, the safety rods drop into the reactor core in about one second. L-Reactor has 66 safety rods made of cadmium, an effective neutron absorber.

Control rods

When a shutdown (scram) signal is received, in addition to the safety-rod drop, the 61 clusters of control rods are automatically driven into the reactor. The control rod system is designed such that the reactor is subcritical

Table G-4. Range of operating variables in SRP reactor charges

Variable	Range
Thermal neutron flux (full power)	5×10^{13} to 7×10^{15a} n/(cm ²)(sec)
Reactor power (full power)	650 ^a to 2915 MW (thermal)
Assembly power	Up to 21 MW (thermal)
Prompt coefficient	$+2 \times 10^{-5}$ to -15×10^{-5} k/°C ^b
Moderator coefficient	-1×10^{-5} to -35×10^{-5} k/°C
Reactivity in control rods	Up to 30% k at cycle beginning; to 0.5% k at cycle end
Reactivity in xenon after shutdown	Up to 60% k
Irradiation cycle length	4 ^a to 400 days
Fuel heat flux	Up to 914 watts/cm ²
Total D ₂ O flow	341 to 619 m ³ /min
D ₂ O flow per assembly	Up to 66.2 l/sec
Assembly coolant velocity	Up to 22 m/sec

^aSpecial high-flux charge.

^bOverall temperature coefficient (prompt plus moderator) is always negative. k is the multiplication factor of the reactor--effectively the number of neutrons present at the end of a neutron generation for each neutron present at the start of that generation.

Table G-5. Nominal values of operating parameters for typical L-Reactor charge

Operating parameter	Plutonium producer (mixed-lattice)
Principal fuel	Enriched uranium
Principal target	Depleted uranium
D ₂ O flow (m ³ /min)	
Per fuel	1.59
Per target	0.89
Total reactor	587
D ₂ O velocity (m/sec)	
Fuel	5.8
Target	7.6
H ₂ O flow (m ³ /min)	672
Power, MW (thermal)	
Per fuel	7.4
Per target	2.5-4.8
Total reactor	2350
Fuel surface heat flux, watts/cm ²	220
Assembly effluent D ₂ O temperature, °C	
Fuel	113
Target	85-110

when the control rods are inserted and the safety rods are withdrawn. The control rods can be driven in singly, or by a gang drive; the rate of insertion is less rapid than that for the safety rods.

Scram instruments

The scram circuits monitor reactor operation and will cause the safety rods to fall and the control rods to drive in. The scram instruments for a particular variable (e.g., neutron flux, coolant pressure, etc.) are set to produce a scram at the operating limit imposed for safe operation. A reactor scram at the setpoint will prevent damage to the fuel and the reactor. The scram, or shut-down instruments, installed in L-Reactor are listed in Table G-6.

Table G-6. Automatic scram circuits

Variable measured	Number provided ^a
Neutron flux (High-level flux monitor)	Four
Operability of neutron flux monitors	One
Rate of change of neutron flux (period)	Two
D ₂ O plenum pressure	Two
Blanket gas pressure	Two
H ₂ O supply header flow	One for each of two H ₂ O headers
Individual heat exchanger H ₂ O flow	One for each of 12 heat exchangers
Control rod coolant supply pressure	One
Moderator level	One
D ₂ O pump a.c. power supply	One for each of six pump motors
Assembly coolant flow	600 in L-Reactor
Assembly average effluent temperature ^b	600 in L-Reactor
Control system power supply	One
Seismic activity	Two of three coincidence
Operability of safety computers	One

^aA manual scram circuit is also provided.

^bFour thermocouples in each of 600 monitor pins provide maximum and average assembly effluent temperature. Monitoring and scram signals are provided for each of the 2400 monitoring thermocouples.

Supplementary safety system

The supplementary safety system (SSS) is a fully independent system that acts as a backup shutdown system. The SSS can be actuated manually or automatically if safety rods fail to shut down the reactor. When the system is activated, gadolinium nitrate, an effective neutron absorber, is injected into the moderator. The SSS is designed such that the reactor will be subcritical even if all safety and control rods are in the fully withdrawn condition. The system has redundant tanks, piping, and valves.

Automatic backup shutdown-safety computer (ABS-S/C)

The ABS-S/C is a backup system that consists of two computers, each of which monitors an average of 300 assembly effluent temperatures and flow every 0.36 second, and which will actuate the SSS to shut down the reactor if the safety rods fail to reduce reactor power in the event of a scram. It will terminate all identified transients for which the primary shutdown mechanism, safety-rod insertion, fails.

Automatic backup shutdown-gang temperature monitor (ABS-GTM)

The ABS-GTM is a second automatic backup shutdown system that is independent of the safety-rod scram system. The sensors are dual monitor pin thermocouples in three fuel assembly positions associated with each of the three gangs of control rods. The sensors are set to actuate the SSS when monitored assembly effluent temperatures approach specified limits.

G.3.1.3 Engineered safety and support system

In addition to the systems discussed above, there are a number of other engineered reactor safety and support systems which help mitigate the consequences of an accident. Several of these systems are described below.

Emergency cooling system (ECS)

The ECS is designed to remove decay heat following a reactor shutdown by the direct addition of light water to the reactor core in case of loss of heavy-water coolant or circulation. Four sources of light water are available, at least two of which have to be online for reactor operation.

1. A diesel-driven booster pump which supplies H_2O from the 95-million-liter 186-L basin.
2. A header with a diameter of 107 centimeters pressurized by five pumps drawing H_2O from the 95-million-liter basin.
3. Another header with a diameter of 107 centimeters pressurized by five additional pumps.
4. A line directly from the river water supply line, pressurized by the river water pumps.

The ECS is actuated automatically as liquid level decreases in the reactor tank or manually as abnormal conditions dictate. When the ECS is actuated, the diesel-driven booster pump starts, and valves are automatically opened or closed to couple the reactor with the primary sources of light water. Borated water from the storage header will be injected into the reactor first, to prevent a reactivity transient when the light water displaces D_2O in the reactor core.

Water removal and storage

If the heavy-water system ruptures, the heavy-water and light-water emergency cooling water would flow to sump pumps in the basement of the reactor building. The sump pumps deliver the water first to a 225,000-liter underground tank; the flow is then diverted to a 1.9-million-liter tank that sits in the 190-million-liter emergency earthen basin. Some of the water on the 0-level process room floor would drain directly to the 1.9-million-liter tank. If this tank should become full, the additional water bypasses the tank and flows into the emergency basin. The 1.9-million-liter tank is vented to the activity confinement system in the reactor building. Because the volume of the 1.9-million-liter tank represents about 10 times the reactor D_2O volume, no moderator is expected to reach the emergency basin. Hence, no tritium or fission product is expected to be carried into this basin.

Airborne activity confinement systems

L-Reactor has an airborne activity confinement system. In the event of an accident, airborne fission products may be released into the reactor room, and possibly into the heat-exchanger bay or the pump room. As shown in Figure G-1, the air from these areas is exhausted through a set of confinement filters before it is released to the stack. During normal operation, the process areas are maintained at a pressure that is lower than the pressure of the external atmosphere to ensure that all air from the process areas is exhausted through the activity confinement system.

Three large centrifugal fans exhaust the air from the process areas. Two of these fans normally are online, but only one is necessary to maintain the negative pressure. The air flow from a single fan is enough to prevent the overheating of carbon filters that might be caused by high retention of radioactivity after a severe accident. The three fan motors can be powered simultaneously by two electric sources:

1. The normal building power through at least two substations
2. The emergency building power from diesel generators.

In addition, each of the three fans has a backup motor, any two of which can be powered by dedicated diesel generators. Exhaust filters remove moisture, particulates, and halogens. The filter banks are enclosed in five separate compartments; three to five of these compartments are normally online at one time. Each compartment can be isolated for maintenance and testing; each contains the following filter banks, in the order of air-flow treatment:

1. Moisture separators, designed to remove about 99 percent of entrained water (spherical particles measuring 1 to 5 microns) to protect against a significant blinding of the particulate filters.
2. Particulate filters, designed to retain more than 99 percent of all particles with diameters of 0.3 micron or larger.
3. Activated carbon beds that use an impregnated carbon to retain halogen activity if an accident were to occur. Special impregnants have been developed to improve the retention of organic iodide compounds. The effectiveness of these filters is discussed in Section G.5.1.2.

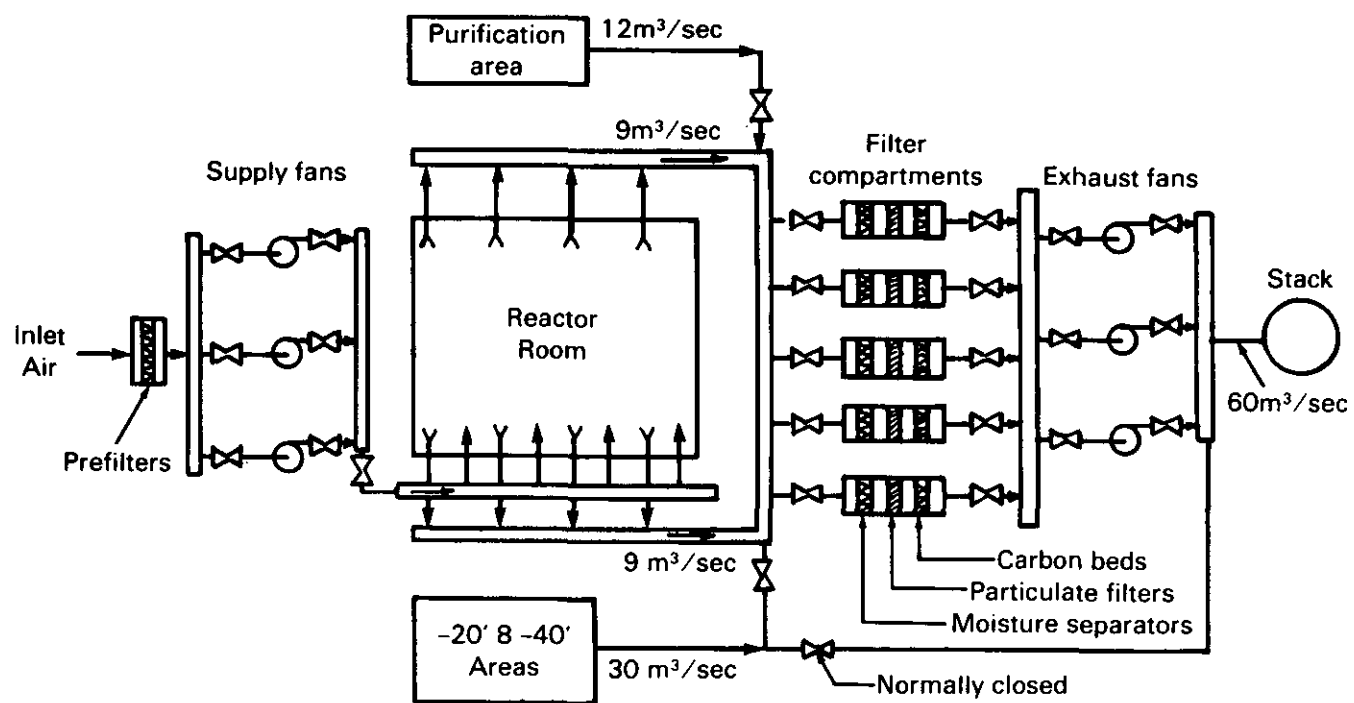


Figure G-1. Reactor activity confinement system.

Confinement heat removal system

A confinement heat removal system (CHRS) is provided to prevent failure of the confinement system in the event of a postulated meltdown of a reactor core. Such a meltdown could occur from the nuclear decay heat if both normal cooling and emergency cooling fail. The CHRS provides limited water flooding on the 40-foot-level floor to cool any molten core material that may penetrate the reactor tank or process pipes.

The source of water for the CHRS is the disassembly basin. Only the top 1.4 meters of disassembly basin water can be drained onto the 40-foot-level floor. The remaining basin water still maintains adequate shielding and cooling for fuel elements stored in the basin. There is a system to provide makeup water to the disassembly basin from two sources.

Reactor room spray system

A system is provided in the reactor room to spray water on an irradiated assembly if one is accidentally dropped during unloading operations. This system consists of a header with twelve groups of fixed spray nozzles mounted on the reactor room wall. The spray pattern from these nozzles covers the area traversed by the discharge machine. Each spray nozzle group has its own actuation valve.

Component handling-cooling during discharge operations

During the interval between removal of irradiated fuel (or targets or other heat-producing assemblies) from the reactor and insertion in the cooling basin, the irradiated assemblies are cooled by water. Five sources of water are available to the discharge machine through four independent paths. Except at the final point of discharge to the assembly, each system has separate hoses, pipes, and actuation valves.

In normal practice, primary H_2O cooling is started automatically as soon as the assembly is withdrawn from the reactor and the water pan swings under the assembly. If primary H_2O flow stops, a secondary H_2O source is switched on automatically. Primary and secondary D_2O cooling is automatically available if the assembly is partially in the reactor, or if the assembly is over the reactor and the water pan does not move under the assembly.

The reactor room spray system is available if an assembly is dropped onto the floor of the reactor room. Assemblies are not discharged unless the maximum decay heat generation rate is less than could be dissipated by the discharge machine cooling water or by natural convective cooling in the disassembly basin if the assembly is dropped and lies in a horizontal position.

G.3.1.4 Electric power

Electric power from the SRP power grid is supplied to L-Area by two 115-kilovolt transmission lines. These lines enter L-Area from two directions. There are also three 30,000-kilovolt-ampere transformers in the area that are connected to the 115-kilovolt grid. Each transformer can carry the L-Area load.

Emergency power for the reactor building is furnished by diesel generators. Two 1000-kilowatt a.c. generators supply emergency power to the reactor building if normal power fails. Eight 103-kilowatt d.c. generators supply power to the process pump motors that maintain the cooling-water flow to the shutdown reactor if the normal a.c. power fails; six of these generators are normally operated at all times, and the remaining two are on standby. Four other diesel generators are located throughout L-Area and provide backup power for ventilation fans, street lights, and other equipment.

G.3.1.5 Process and effluent monitoring

All gaseous radioactive releases through the stack are monitored continuously by gamma spectrometry. Stack-effluent tritium is monitored by two ion chambers that operate in parallel. Moisture is removed from the air to one of the chambers to provide a differential current between the chambers. A continuous sampling technique with daily quantitative analysis is also used. All other air and water samples are monitored routinely; quantitative release records are kept. Above-normal activity levels are investigated to locate the source so the condition can be corrected.

Samples are analyzed routinely to quantify the key surveillance radio-nuclides from the following sources:

1. The moderator
2. The stack exhaust air
3. The effluent heat-exchanger cooling water
4. The disassembly-basin effluent purge water

G.3.2 Site features

G.3.2.1 Site location

The Savannah River Plant occupies an approximately circular area of about 800 square kilometers. The L-Reactor site is located in the south-central portion of the Savannah River Plant.

G.3.2.2 Site description

The predominant site feature that would mitigate the consequences of an accident at the L-Reactor is the distance of 9 kilometers to the nearest SRP boundary. Although South Carolina Highway 125 is only 5 kilometers from L-Reactor, there are procedures for stopping traffic and clearing all personnel off the highway within a short time of any incident at the SRP.

G.3.3 Emergency preparedness

G.3.3.1 Emergency planning - onsite

An onsite Emergency Operating Center (EOC) is maintained at SRP to provide immediate and informed response to any site accidents. The responsibility for emergency response at the plant facilities (including L-Reactor) within the Savannah River complex is clearly defined (DPSOP 67 and 129). Adequate staffing to provide initial facility accident response in key functional areas is maintained at all times. Timely augmentation of response capabilities is available and the interface among various onsite response activities is clearly specified (DPSOP 129).

Patrol EOC personnel operate from the communications room 24 hours a day, 7 days a week, using radio and telephone equipment that links all patrol installations throughout the plant. During emergencies, specialized communications equipment is operated to contact production control rooms, local law enforcement agencies, state and Federal radiological agencies, state and local government officials and others, as required by the specific emergency.

Accident emergency classifications and action-level schemes have been established (DPSOP 129 and 175). There are provisions for prompt communications among principal response organizations and emergency personnel (DPSOP 129).

The EOC is equipped with self-contained power and service facilities and a shelter capable of housing 20 persons for 30 days under emergency conditions. The center has blast doors, air locks, and an emergency escape hatch. The EOC will withstand blast pressures to 15 psi and provides a radiation protection factor of up to 6000. It can be completely isolated from the outside environment in about 5 minutes. The EOC is also equipped with air filters for emergency use. A sand filter system is underground in a blast-resistant concrete structure. There are also two carbon filters in series. The first unit will absorb chemical warfare gases; the second unit will absorb radioactive iodine.

The EOC shift crew and meteorological operations center contains radio and telephone equipment for all necessary communications in handling response to an emergency condition (DPSOP 129 and 307). Equipment is also available for monitoring a release from the reactor areas and obtaining critical data from instrumentation in an uninhabited reactor building. The Weather Information and Display (WIND) system terminal provides facilities to accurately predict downwind hazards from chemical and radioactive releases. Maps and plotting equipment allow a visual organized presentation of the data for EOC staff personnel. Equipment is also available for monitoring radiation and chemical hazards to personnel occupying the EOC.

The EOC staff room contains a comprehensive communications network permitting the DOE-SR and Du Pont staff to monitor communications on the patrol and emergency radio networks and also to monitor telephone conversations between the Area Emergency Coordinator at the incident site and Production and Technical Management personnel in the EOC. Copies of Emergency Procedures, pictures of vital process equipment and process schematics, maps, television monitors and a number of other visual aids are available for use by EOC staff liaison personnel in keeping the EOC staff informed concerning the status of an emergency. Future

information and communications improvements, either authorized or planned, include a remote detection and control (REDAC) terminal from the reactor areas and a plantwide cable television network that will provide video and audio communications between the Plant Production areas and the EOC.

During an emergency situation the organizational and emergency procedures and responsibilities are clearly defined and shared between Du Pont and the Department of Energy (DOE). Procedures for notification of emergency occurrences to state and county officials exist through current memoranda of understanding.

An Offsite Communications Center (OCC-A) is also maintained in Aiken, South Carolina. The purpose of the OCC-A is to assure a communications link with Savannah River Plant if (1) highways to SRP are impassable, (2) telephone lines are inoperative due to overloads, or (3) the Emergency Operating Center is not accessible. The OCC-A also provides an offsite location for EOC staff members or key personnel during a national or local emergency.

In the event of emergency assignment to OCC-A, Du Pont and DOE-SR management representatives would serve as liaison between the EOC staff and offsite personnel, using a direct telephone line from OCC-A to the Emergency Operating Center. A monthly check of this line is made to ensure operability. The OCC-A also contains a radio with SRP Patrol, SRP Emergency, and DOE-SR net channels. Maps, copies of emergency procedures, and other visual and briefing material are also located in the OCC-A.

As required, the OCC-A can serve as a location for use by DOE-SR Office of External Affairs personnel to brief media representatives. It could also be employed as a temporary office location for a small number of representatives from state and Federal agencies, or for local government officials.

The Dwight D. Eisenhower Army Medical Center, Ft. Gordon, Georgia, is also on call to respond to the medical requirements of the SRP (DPSOP 129). All other facilities, communications, and emergency resources are maintained within the Savannah River complex (DPSOP 129 and 175).

A minimum of four emergency training exercises are conducted annually to test and evaluate the performance of EOC personnel and equipment.

G.3.3.2 Emergency planning - offsite

South Carolina and Georgia, and their respective counties of Aiken, Allendale, Barnwell, and Burke and Richmond have existing Emergency Response Plans in varying degrees of completeness. State and county officials are being assisted by DOE in fully developing their respective Emergency Response Plans. These plans are discussed further in Appendix H.

G.3.3.3 WIND system

The Weather Information and Display (WIND) system is an automated emergency response system for real-time predictions of the consequences of liquid and atmospheric releases from the Savannah River Plant (Garrett, 1981). The WIND System has been developed over the last 10 years specifically for use at Savannah River Plant. Site-specific features of the system include meteorological towers at each production area that are instrumented at the stack height, computer terminals at each production area that can be used to run the emergency response codes remotely, codes which use empirical information on atmospheric diffusion and deposition gathered at Savannah River Plant (Carlson et al., 1982; Buckner et al., 1975), and stream transport and diffusion codes that have been calibrated with dye tests in the SRP streams (Garrett and Murphy, 1981).

The SRP Health Protection Department staffs all production areas 24 hours a day with technicians who are trained to run the WIND system emergency response codes in addition to the four meteorologists, a computer system manager, a field engineer and 3 technicians who comprise the basic team that operates the WIND system.

Computer codes have been developed which allow display of latest or archived meteorological data from the SRP towers or Automatic Forecasting and Observation System (AFOS); trajectory, concentration, deposition, and dose calculations for atmospheric releases; concentration calculations for releases to SRP streams; and estimates of reactor core melt based on stack monitor data. Dose calculations include inhalation doses and whole-body doses caused by gamma radiation from noble gases and iodine. Atmospheric transport and diffusion codes range in complexity from Gaussian trajectory models (Cooper and Rusche, 1968) that can be run in less than 5 minutes, to two- and three-dimensional codes that require about 1 hour of computations.

G.4 ACCIDENT AND IMPACT ASSESSMENT

As a means of assuring that L-Reactor features meet acceptable design and performance criteria, the potential consequences of a number of postulated transients have been evaluated. These postulated transients or accidents are used to help establish system design characteristics and operating limits. They are described in the following subsections. These subsections also describe the results of analyses used to estimate the possible impacts and risks associated with a group of four postulated severe accident sequences--with a low probability of occurrence--that could release significant radioactivity to the environment. The consequences to persons offsite are described in Section G.5. The potential radiological consequences for all of these postulated incidents cover a considerable range of values depending on the particular course taken by the accident and the conditions, including meteorology, prevalent during the accident.

G.4.1 Postulated transients and accidents

The postulated transients and accidents considered in the safety analysis and evaluation of L-Reactor include all incidents listed in Table G-1. Four hypothetical severe accidents are specified to cover a spectrum of credible events postulated to release significant quantities of radioactivity. |TC

All reactor-related accidents share the common characteristic of too much power for too little cooling. Accident analyses can be grouped into three broad classes.

1. Reactivity addition (equivalent to removal of neutron absorber) that increases reactor power or power in a local region of the reactor.
2. Flow reduction, caused by loss of pumping power, reduction of circulation, or loss of coolant, that reduces the cooling capacity of the reactor or individual heat-producing assemblies. The loss of moderator will be considered in this class.
3. Non-nuclear types of accidents that are not directly related to rapid changes in the reactor conditions.

For all of the accidents analyzed, the reactor would be shut down by the primary or redundant shutdown systems before:

1. Reactor tank is damaged, or the
2. Confinement system is breached.

The radiological consequences of incidents often called anticipated operational occurrences, fall within limits of normal operational releases of radioactivity. The key postulated transients in this class are all incidents listed in Table G-1 with the possible exceptions of incidents 4 through 7, 16, and 18. Many are credible but have a very low likelihood of occurrence. Incidents 1, 2, 7, 12, 13, 14, and 15 have a nontrivial occurrence record among all of the SRP reactors.

The following discussion addresses each transient in Table G-1.

G.4.1.1 Single control-rod withdrawal

The reactor is assumed to be operating at full power at operating limits. The control rod withdrawn is adjacent to the hottest assembly in the reactor. Withdrawal is at the maximum rate possible requiring two minutes to move from the full-in to the full-out position. The hypothesized withdrawn rod is near the edge of the reactor, thus causing a radial power tilt as well as an increase of local reactor power.

Occasional unwanted control rod motion is expected to occur at L-Reactor. Reactor and hottest assembly powers would increase until scram or cessation of rod motion. In a limiting case, the reactor power increases almost linearly at a rate of 0.4 percent per second, while the hottest assembly power increases at about 1.9 percent per second. Primary scram is based on the assembly coolant |TE

temperature monitor in the hottest assembly. Secondary scram is based on nearby assembly coolant temperature monitors or high-level flux monitors. The accident is analyzed for every reactor charge to establish normal operating limits and is analyzed generically to establish confinement protection limits. The operating limit on assembly coolant flow and coolant temperatures is set so that a reactor scram would prevent the coolant from reaching the saturation temperature. Under this condition there would be no damage to fuel or reactor, and radioactivity would not be released to the environment.

G.4.1.2 Partial control-rod movement

The partial rod is assumed to be centered axially in the reactor at the position of maximum absorption. The rod drives in or out at the maximum speed of 0.136 and 0.118 foot per second, respectively. The partial rod is in a control cluster near the side of the reactor, thus causing radial power tilting. Axial power distribution changes as well as radial power distribution changes will occur.

Unwanted partial rod motion is expected to occur occasionally. The scram bases are the same as for single control-rod withdrawal. Reactor and local power increases are less than or equal to those caused by unwanted full rod withdrawal. Analysis considerations are the same as for full rod withdrawal (Section G.4.1.1).

G.4.1.3 Gang-rod withdrawal at full power

Groups of control rods called gangs are moved together in normal reactor operation. Gang I consists of the inner 19 clusters of control rods, Gang II the next ring of 18 control clusters, and Gang III the outer ring of 24 clusters. The reactor is assumed to be at full power at operating limits. A gang of control rods moves out continuously at maximum speed. Significant radial power perturbation cannot occur.

Unwanted continuous gang withdrawal is not expected to occur. Short-term withdrawal, because of spurious signals in the control computer, might occur. Reactor power and hottest assembly powers would increase until scram or cessation of rod motion. Reactor power would increase at a rate of 1.2 percent per second, while the hottest assembly power would increase at 1.7 percent per second. Primary scram is based on assembly coolant temperature monitors. Secondary scram is based on high-level flux monitors (can be the primary instrument). The gang-rod-withdrawal accident is analyzed for both transient protection limits and confinement protection limits. This accident is often the most restrictive in setting reactor operating limits.

G.4.1.4 Gang-rod withdrawal at low power

It is assumed that inadvertent gang withdrawal occurs three decades (a factor of 1000) below full power (at 1 to 3 megawatt thermal). The inventory of

xenon-135, which has a very large neutron cross section, is at or near maximum. At full power, xenon-135 absorbs about 3 percent of all neutrons produced in the reactor, but when the reactor is shut down, the inventory of xenon-135 increases by decay of iodine-135 to several times its full power inventory. If the reactor were restarted with a large inventory of xenon-135, its burnup would add reactivity that could exceed that caused by control rod withdrawal. Temperature coefficients do not provide sufficient negative feedback to prevent a rapid power rise until the reactor power reaches levels within a decade of full power.

This gang rod withdrawal at low power is expected to have the same frequency of occurrences at full power. Reactor power would increase at rates greater than for gang withdrawal at full power, because of the xenon-135 burnup. Primary scram is based on high-level flux monitors and period (rate of flux increase) monitors. Secondary scram is based on assembly coolant temperature monitors at about 50-percent full power. The accident is analyzed for each type of charge. For certain high-level flux charges, restrictions are placed on the time for xenon to decay before the reactor can be restarted.

G.4.1.5 Control-rod melting

If, based on control-rod heat flux, control-rod melting is possible for the reactor charge design being analyzed, it is postulated that:

1. Control-rod heating and melting occur adiabatically
2. The neutron-absorbing material disappears from the reactor as soon as melting occurs
3. Partially inserted rods are severed at the midplane by melting, allowing the lower part to drop
4. The control rods melt in clusters on the outside of the reactor

Control rods can melt because of possible reduced cooling, provided they have sufficiently high power density. Reactor power increases are similar to those for single-rod withdrawal accidents, although the rate of reactivity addition is different. Effluent temperature monitors for assemblies in the affected control cluster would cause a scram. For a septifoil with no forced flow (unseated), control-rod melting has been analyzed to begin with film-boiling burnout at a heat flux of 102 watts per square centimeter. Typical maximum heat flux values for current charges are 57 to 74 watts per square centimeter. The control-rod melting accident is not considered in establishing limits if the maximum heat flux in the charge is less than the 102 watts per square centimeter value calculated to be required for control-rod melting.

G.4.1.6 Loss of target

The analysis of a loss-of-target accident is an effort to conceive of all possible means by which reactivity could be added to the core. The postulated loss of target is the consequence of an extremely improbable loss of cooling to

only a single target and should be considered in that context. It is assumed that an abrupt reduction in coolant flow occurs in a high-power target. No known mechanism exists to cause such a reduction in flow. The target assembly is assumed to melt, whether the reactor is shut down immediately or not. The target material disappears from the reactor as soon as the target melts, which increases reactivity. If a high-power target assembly should melt, reactivity could be added at a rate greater than that for control rod or gang rod withdrawal. The flow monitor for the afflicted target assembly would be the first scram instrument to respond. The secondary scram circuit would be the assembly coolant temperature monitor. The course of the accident would be trivial if the safety-rod scram system performed as designed. If the safety-rod scram should fail, core damage would be prevented by the automatic backup systems.

Loss-of-target accidents are not considered in deriving transient protection limits because the postulated large, and abrupt, loss of flow is considered so improbable. More realistic reductions in flow to individual assemblies are considered for operating limits. The loss-of-target accident is considered for conservatism in establishing confinement protection limits.

G.4.1.7 Loss of fuel

The analysis of a loss-of-fuel accident, like the loss-of-target accident, is an effort to identify all conceivable reactivity addition transients independent of currently accepted credibility arguments. Again, the assumption is made that a sudden, abrupt loss of flow (for which no initiating mechanism has been identified) occurs to a fuel assembly. The fuel assembly melts, and some of the molten debris from the uranium-aluminum alloy fuel may be entrained and reach the moderator where it would then be exposed to a higher neutron flux than in its usual pre-melt condition. The exposure would cause a temporary increase in reactivity, until the debris is swept from the reactor core. Simultaneously, steam voids formed in the moderator around the fuel particles would decrease reactivity.

The primary scram instrument is the assembly flow monitor. Secondary scram instruments are the high-level flux monitors and assembly temperature monitors. Even with the conservative assumptions used for this accident, the calculations to assess this accident indicate that the primary and backup shutdown systems provide adequate protection.

G.4.1.8 Reloading error

A reloading error is the basis for one of four hypothetical events postulated to cover the spectrum of accidents that could have a significant impact on the environment.

The reactor is shut down and the charge-discharge operation is in progress in a mixed-lattice charge. It is assumed that an error is made when irradiated targets are discharged from adjacent positions without charging fresh targets to these positions, or in spite of mechanical interlocks, fuel assemblies are

charged to target positions. It is further assumed that charge design constraints have failed, and the reactor becomes supercritical.

The result of the postulated accident could be fuel melting and radioactivity release to the reactor building. The scram system is ineffective because the safety and control rods are already in the reactor. The Supplementary Safety System is much less effective than at full power because of the reduced moderator and coolant circulation rate required during charge-discharge operations. The neutron flux changes caused by reloading errors are highly localized and therefore the two fission counters external to the reactor core might not detect the error.

To help avoid this potentially serious accident, each reactor charge is analyzed to search for the worst possible reloading error. The charge is designed such that it does not become critical during this error. An improved monitoring system, consisting of six internal fission chambers, has been designed, tested, and installed in L-Reactor.

The course of a postulated power excursion caused by reloading errors has been calculated. The highly localized damage involves less than 3 percent of the core.

Reloading accidents are not considered in establishing normal operating limits because full-power parameters are not involved. Nor are they weighed against the conventional criterion for confinement protection because the reactor coolant system is open to the atmosphere during reloading. However, calculations have shown that the confinement system integrity is not seriously challenged by this accident.

G.4.1.9 Loss of D₂O coolant pump power

Loss of all offsite a.c. power is a credible event. The onsite a.c. power generation is insufficient for simultaneous full-power operation of all SRP reactors. Thus, it is assumed that loss of a.c. power could occur for any reactor, and further that a.c. power to the six D₂O coolant pumps is lost simultaneously. The d.c. motors to the pumps continue to supply power and would maintain flow at 29 percent of full flow. Flywheels between the pumps and motors slow the flow decay transient.

As the flow decreases, fuel and target assembly effluent temperatures increase. The increased water temperature produces a negative reactivity, which causes reactor power to drop slightly in the first 2 seconds. The first scram instruments to respond would be the two plenum pressure monitors. These are backed up almost immediately by the assembly coolant flow monitor.

The accident analysis is used to set both transient protection and confinement protection limits. The safety-rod scram would limit the maximum coolant temperature to a value at least 7°C lower than the saturation temperature. If the safety rods are ineffective, the ABS-S/C would limit coolant temperatures to about 5°C less than the saturation temperature. If both a.c. and d.c. power were lost (for which no mechanism has been identified), flow would continue to decay until either some pumping power is restored or emergency coolant is

introduced. This accident is considered separately as the loss of D₂O circulation accident.

G.4.1.10 Loss of H₂O pump power

The loss of H₂O pump power is a credible event. It is assumed that electrical power is lost to the pumps supplying H₂O directly to the reactor heat exchangers. The H₂O flow decreases to 25 percent of normal sustained by gravity flow. Gravity flow is assured by the difference in elevation of the cooling water basin and the heat exchangers at -20 ft.

TE| As a result of the decrease in H₂O flow, the temperature of the D₂O leaving the heat exchangers and entering the reactor would increase. This would increase the D₂O outlet and fuel assembly effluent temperatures. Reactor power would decrease because of the negative temperature coefficient of the reactor charges. The fuel coolant temperatures change more slowly than for a loss of D₂O pump power. The scram instruments to respond first would be the 12 heat exchanger flow monitors, followed by the two H₂O header flow monitors and the fuel assembly effluent temperature monitors.

The accident is not used to establish reactor operating limits because the transients are slow compared to other flow reduction accidents. The temperature of the hottest assembly would be 19°C below the saturation temperature (coolant boiling) at shutdown caused by the ABS-S/C. The accident is used in establishing confinement protection limits.

Alternative forms of this accident have been postulated. Clearly, a partial loss of pumping power would yield a less severe flow transient than the total loss of power considered here. Plugging or breaking a line to an individual heat exchanger would be still less of a perturbation. A break in an H₂O supply header could, if the break were large enough, cause a more severe flow transient than loss of pumping power. The response of D₂O temperature to such an improbable abrupt and total loss of H₂O cooling has been calculated. It was found that effluent temperatures hardly change before a safety-rod scram (triggered by H₂O flow monitors) shuts down the reactor. If H₂O cooling is not restored, then the assembly and reactor effluent temperatures would eventually increase because of fission product decay heat. Manual actuation of the ECS would then be required, but the accident would be less severe than the loss-of-circulation accident. No melting would occur.

G.4.1.11 Loss of both D₂O and H₂O pumps

The possibility of simultaneous loss of a.c. power to both D₂O and H₂O pumps has been considered as an extreme extension of either of the accidents considered singly. However, analysis shows that the accident of D₂O flow reduction increases coolant temperatures so much more quickly than H₂O flow reduction that the two accidents are essentially independent. In the event of loss of both D₂O and H₂O pumps, coolant temperatures increase at the same

rate as for loss of D₂O pumps only. Thus, the combined case is not considered in establishing operating or confinement protection limits.

G.4.1.12 Pump shaft break

This accident is conceivable but not likely to occur because of over 600 pump years of operation without failure and because of frequent inspections. It is assumed that a pump drive shaft breaks between the D₂O pump impeller and the flywheel when the reactor is at full power. The impeller is left free to rotate, which allows a reversal of flow through the pump.

If a shaft breaks, the fluid momentum drops to zero (and reverses) much more quickly than if a D₂O pump should lose power (because the energy stored in the flywheel would reduce the rate of decrease in flow). The resulting flow changes in the reactor are asymmetric--the fuel and target assemblies in the affected coolant sector have a greater flow reduction than other assemblies in the reactor. Some assembly flows reduce to 75 percent of normal in 2 seconds, while average assembly flows reduce to slightly greater than 80 percent normal. The primary scram instruments are the plenum pressure monitors, followed by the assembly flow monitors.

Analysis of the pump shaft break accident is used in deriving operating and confinement protection limits. The safety-rod scram would prevent the assemblies from melting. The maximum assembly temperature can exceed the boiling point if the safety rods fail to drop. Reactor limits are set such that if this happens, the steam generated does not produce a force great enough to lift the plenum. The steam generation lasts for too short a time to cause any assemblies to melt and release radioactivity.

Analysis of the case in which the broken pump shaft freezes and prevents the impeller from turning has been compared with the analysis in which the impeller is left free to rotate. The latter case produces the more restrictive limits.

G.4.1.13 Rotovalve closure

Although spurious rotovalve closure is possible and has occurred, the combination of closures specified for the postulated transient has never occurred and there is no known mechanism for an occurrence. Rotovalves are installed in the six external loops of the D₂O circulation system between each of the 12 heat exchangers and the reactor plenum. During normal, full-power operation, the rotovalves are fully open. During maintenance work, the rotovalves are fully closed to prevent loss of D₂O. It is assumed that the two rotovalves in each of two external loops close simultaneously when the reactor is at full power.

The flow reductions have been calculated for simultaneous closure of the four rotovalves. Flow in the minimum flow assembly after 2 seconds is about 97 percent of normal, compared with 75 percent of normal flow at 2 seconds for a pump shaft break accident. The difference between the maximum expected assembly

effluent temperature and the saturation temperature is large compared with the difference for a pump shaft break accident.

The primary scram instruments are the plenum pressure monitors and the assembly flow monitors. Postulated rotovalve closure incidents are not used to set transient protection limits, because this incident always yields higher limits than the pump shaft break incident. Postulated rotovalve closure incidents are used to set confinement protection limits.

G.4.1.14 Flow reduction in a single assembly

It is assumed that a gradual reduction in flow occurs to a single coolant channel within an assembly. This could be caused by the swelling that accompanies a cladding failure in a uranium fuel or target assembly. Fuel failures resulting in flow reduction have occurred at SRP.

As assembly flow gradually decreases, the assembly channel effluent temperature gradually increases. The assembly coolant flow monitor would be the first to scram the reactor. The scram setpoint for the monitor is required to be at the point that would prevent coolant boiling in the hot channel. The assembly effluent temperature monitors are also set to prevent boiling in the hottest channel. This flow reduction incident is used to determine transient protection limits for the reactor. One other case is considered in establishing confinement protection limits. This is the abrupt and complete flow reduction that is postulated to lead to the loss of assembly accidents already discussed. No specific initiating mechanisms have been identified for this abrupt flow reduction.

G.4.1.15 Loss of control-rod cooling

Flow reduction or blockage in the header supplying cooling to the control rods, or in the individual septifoil housing the control rods is unlikely because there are strainers in the headers and because heat exchangers with much smaller flow passages are upstream. Instead of a flow blockage, it is assumed that the septifoil housing is unseated in the reactor, thus reducing the flow to zero.

For this transient, calculations show that for current charges control-rod temperatures increase, but damage or melting does not occur because the calculated control-rod heat flux is not in excess of a high specific limit. If the heat flux exceeds the limit, then a control-rod melt accident is considered.

A reduction in header flow would cause a reactor shutdown within 2 seconds and prevent any damage. If a control rod should melt because of very high heat flux and septifoil unseating, then the assembly effluent temperature monitors around the affected cluster would shut down the reactor. No fuel or target assembly damage would result.

G.4.1.16 Loss of blanket-gas pressure

Slow leaks of blanket gas have occurred at Savannah River Plant, but not a sudden rapid drop in pressure. It is assumed that a blanket-gas leak reduces the blanket-gas pressure linearly from 0.136 to 0 MPa in 2 seconds. This loss of blanket-gas pressure would reduce the saturation temperatures in the reactor and cause evolution of the helium gas dissolved in the D₂O. Other secondary results follow. Cavitation may occur in the external cooling loops, which would reduce reactor coolant flow and increase coolant temperatures. A second consequence of losing pressure is that the dissolved gaseous helium would appear as bubbles in the D₂O, which would cause a negative reactivity effect and drive reactor power down. The lower power would produce a positive reactivity feedback and the power would rise again. A safety-rod scram would occur after 1 second. Power and temperature oscillation could occur because of evolution of helium if the scram did not occur. Oscillations in currently operating charges would be small. However, the ABS-S/C would shut down the reactor after 5 seconds, so that realistically, no oscillation would occur. |TC

The primary and secondary scram instruments are the two blanket-gas pressure monitors and the assembly effluent temperature monitors. Analysis of this accident is used to set transient protection limits. The assembly coolant temperature monitor is required to have its scram setpoint set low enough to ensure that the saturation temperature of the channel exit is not exceeded at a blanket-gas pressure of 0.129 MPa (normal operating pressure is 0.136 MPa). This ensures no reactor damage and thus no release of radioactivity. |TC

G.4.1.17 Loss-of-coolant accident

It is postulated that a leak occurs somewhere in the D₂O coolant system when the reactor is at power. There are two classes of leaks: credible small leaks and a hypothetical, very large, sudden leak.

If a leak rate greater than 15 liters per minute should occur, the moderator level in the reactor tank, the blanket-gas pressure, and the plenum pressure would all decrease. The response would be as follows:

1. Automatically shut down the reactor.
2. Isolate the leak as much as possible.
3. Activate the Emergency Cooling System, if needed, to replace the lost D₂O with H₂O.
4. Maintain circulation to cool the fuel and target assemblies. (One other result of a large leak, the release of radioactivity to the reactor building and the environment, will be discussed in following sections.)

The scram instruments that would be activated are the moderator level, blanket-gas pressure, or plenum-pressure circuits, followed by the individual assembly flow and temperature monitors.

A large effort has been expended on the analysis of credible and hypothetical leaks. An ECS supplied from four independent sources of water can be activated manually or by logic circuits connected to the reactor scram instruments. Analysis shows that no fuel melting would occur for any credible loss-of-coolant accident. Of the credible accidents, the most likely would be a break in one of the smaller pipes in the auxiliary cooling systems. An example would be a break in a pipe supplying D₂O coolant to the septifoil system. The leak rate from this system would be 14 cubic meters per minute; no fuel damage would occur after the ECS was actuated.

The analysis is also made for a hypothetical maximum leak rate--an abrupt, double-ended break of a large pipe accompanied by other circumstances that render two of the three ECS supply systems ineffective. The worst of the accidents analyzed is a break in a line that also serves as one of the lines that would supply emergency H₂O coolant. The accident is not considered credible in the SRP system of stainless steel pipe operating at relatively low pressures of approximately 100 psi. For this hypothetical large leak, the ECS would limit the accident to 1 percent core damage if the ECS were degraded by a valve failure in another ECS supply line.

Shutdown would begin about 1 second after the pipe break. Analysis of the accident indicates that fuel damage does not occur in this 1-second interval. The longer term flow transient analysis indicates that damage may occur later. The factors that enter into the analysis are reactor power, power distribution, reactor flow, flow distribution, ratio of fission product decay power to normal operating power level, the ECS supply rate, and finally the degree of fuel damage established as a function of assembly flow and power. Reactor power is limited to a value that would produce less than 1 percent core damage if this hypothetical maximum leak rate should occur and only one of the three ECS systems were operable. The releases for this accident are discussed in Section G.5.

No fuel melting is anticipated in any credible LOCA. But some radioactivity will be released to the environment in any LOCA. The main contributor to offsite dose is tritium in the moderator (formed from neutron capture by deuterons). The tritium is released mainly by evaporation. The amount released depends on the size of the leak and on the disposition of D₂O leaking from the reactor to the reactor building.

Unless the leak were stopped, the entire inventory of D₂O could be released to the reactor building. This is the basis for the large moderator spill accident which is one of the four hypothetical events postulated to cover the spectrum of accidents that could release radioactivity to the environment. Almost all of the D₂O would be contained in two closed tanks outside the reactor building. Because the only vent path for the tanks is back to the reactor building, any tritium released by evaporation would eventually be discharged through the 61-meter stack. The releases for this accident are discussed in Section G.5.

G.4.1.18 Loss of D₂O circulation

The complete loss of D₂O circulation is considered highly improbable. It is assumed that a complete loss-of-D₂O circulation occurs by loss of all pumping power or some obstruction. Loss of pumping power could occur if all electrical power were lost and the motor room were flooded so as to stop the d.c. motors. Obstruction could occur if all rotovalves were closed, or if the D₂O became frozen.

The loss of circulation would cause a reactor scram, but the ECS system would have to be activated to prevent melting fuel by the remaining decay heat. The addition of H₂O from the ECS would force a moderator-H₂O mixture out of the three pressure relief systems in the reactor tank. As a result of this accident radioactive moderator is released to the reactor building through the pressure relief ports. Even if one of the three ECS lines is inoperable, no fuel melting will occur. The reactor is shut down by numerous flow sensors. The ECS is activated manually by procedural response.

The pre-accident reactor power is adjusted to limit fuel melting to 1 percent of the reactor core. In this sense, the loss-of-circulation accident is considered in deriving reactor power limits. However, detailed analysis of this accident shows that the reactor power that would limit fuel damage to 1 percent is higher than the reactor power prescribed by other limits. Thus, no melting may occur, but radioactive moderator would be released to the reactor building and the environment. The analysis of this accident is also used to define function specifications for the operation of the ECS.

Emergency sump pumps and dams are provided to minimize the possibility of flooding of the motor room.

Another postulated mechanism for losing D₂O circulation is freezing of D₂O in the heat exchanger due to extremely low cooling-water temperature. Operating procedures specify recirculating effluent water if the river water temperature should drop to 5°C. The D₂O freezing point is 3.8°C, and on one occasion (over 30 years of operation), the temperature of the Savannah River came close to this value. But if the water temperature drops below 5°C, some of the hot-water effluent is recirculated to the water in the basin to keep the inlet temperature from falling below 5°C.

G.4.1.19 Loss of cooling during and after discharge

Irradiated fuel and target assemblies are discharged in air and transported by crane to the discharge canal. If the crane becomes disabled, emergency cooling would be required to prevent melting and release of fission products. It is assumed that the crane becomes disabled. This accident is considered credible but improbable. If all four addition paths of emergency cooling to the discharge machine should fail at the same time a discharge machine interruption occurs, melting of fuel could take place.

G.4.2 Disassembly-basin accidents

The melting of irradiated fuel or target components in the disassembly basin is considered to be highly unlikely. Assemblies are not discharged from the reactor until the calculated heat generation rate is low enough to assure adequate cooling, even if the assembly is dropped to a horizontal position. In most cases, the heat generation in fuel and target assemblies immediately after reactor shutdown is sufficiently low that no cooling-off period is required. Should some unexpected assembly damage occur, the radioactivity would be released under about 10 meters of water. The affected basin section would be isolated and the water in that section would be circulated through deionizers and sand filters. Although the disassembly area is not part of the confinement system, most of the airborne release would be filtered by the confinement system as the air from personnel areas is drawn into the lower-pressure process areas and exhausted. In addition the high partition coefficient for iodine in water would cause the majority of the iodine released from the assembly to remain in the water, and no particulates would escape to the atmosphere.

A criticality accident is also an unlikely possibility in the disassembly area; such an accident is strongly guarded against by mechanical and administrative controls. If such a criticality did occur, it would typically involve from 10^{15} to 10^{20} fissions and occur under 10 meters of water. Offsite effects would not be expected to be measurable.

G.5 RADIOLOGICAL CONSEQUENCES OF REACTOR ACCIDENTS

The range of accidents considered for L-Reactor safety has been discussed in Sections G.1 and G.4.1. This section discusses how radioactivity released by accidents may affect the public. The sources of a radioactivity release are discussed first. Then the calculation techniques and finally the results of the calculations are presented.

The spectrum of conceivable SRP reactor accidents covers the range from trivial to severe. Four specific accident cases are cited to illustrate a range of accidents (up to 3 percent damage of the core).

G.5.1 Sources of a radioactive release

G.5.1.1 Isotopes released and manner of release

The sources of radioactivity considered in this section are tritium in the heavy-water moderator and fission products in the fuel. Potential offsite doses from nonfission product isotopes (cobalt-60, plutonium-239, etc.) are considered in Section G.5.5.

G.5.1.1.1 Moderator radioactivity

This report uses a conservative value of 5,000,000 curies of tritium present in the moderator. This is 30 to 40 percent higher than actual present values in currently operating reactors. The tritium is a natural consequence of neutron capture by deuterium. This tritium could be partially released to the confinement system following ECS actuation or any LOCA.

Any tritium becoming airborne in the confinement system would be discharged from the stack, because the confinement system has no mechanism for tritium removal.

It is quite unlikely that the full moderator inventory of tritium would evaporate and diffuse into the confinement system following any accident because the moderator would flow into the two holding tanks of the liquid activity confinement system. It is estimated that no more than about 3 percent of the tritium would evaporate during the initial 2-hour period after the postulated accident.

G.5.1.1.2 Radioactivity available for release from core melting

If any fuel or target assemblies melt, fission products become available for release. Depending on the type of assemblies melting and other circumstances the radioactivity release would include noble gases (xenon, krypton), iodine, and radioactive particulates (fission products, cobalt-60, plutonium-239, etc.). The concentration of these isotopes in the core is a function of reactor power that might reach a maximum of 3000 megawatts. Table G-10 lists the total inventory of fission products. Most of these isotopes decay rapidly following shutdown; and depending on the expected accident sequence, some isotopes may not contribute significantly to potential offsite doses.

The inventory of noble gases and iodine contributing to offsite dose is shown in Table G-7 and Figure G-2. Tritium is present in lithium-containing assemblies and control rods; up to 12 megacuries of tritium may be present in plutonium-producing charges. The radioactive particulates include several different isotopes and would be captured by the HEPA filters. The amount of particulates that would penetrate the filters would not contribute significantly to the offsite dose (Cooper and Rusche, 1968; Durant et al., 1966).

Table G-7. Iodine and noble gas inventory of
3000-MW core (major contributors
to 2-hour offsite dose)

Isotope	Inventory (MCi)	Isotope	Inventory (MCi)
I-131	75	Kr-87	35
I-132	115	Kr-88	75
I-133	175	Xe-133	165
I-134	180	Xe-133m	25
I-135	165	Xe-135	20
		Xe-135m	30

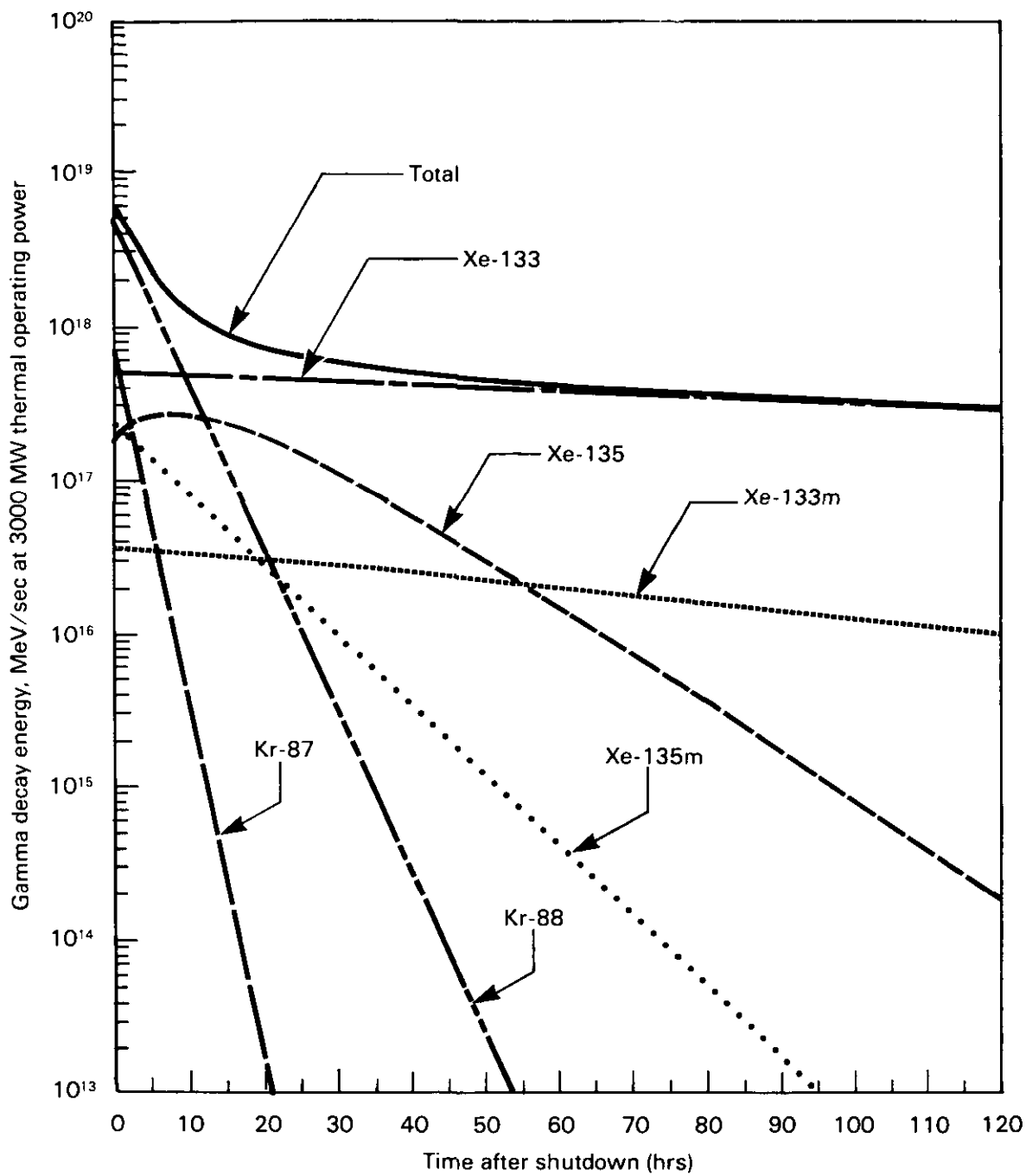


Figure G-2. Gamma decay energy of noble gases.

Three releases of radioactivity from the core are considered as credible in this EIS; they involve melting of a single fuel assembly, 3 percent damage of the core during a reloading accident, and 1 percent damage of the core during a LOCA. TC

Melting of a single assembly during discharge

The fission products in the assembly would have decayed significantly between shutdown of the reactor and the discharge operation. Fourteen hours of decay of fission products is assumed as the minimum time to satisfy other discharge constraints as discussed in Section G.4.1.19.

The reactor room emergency spray system would be used to cool a hot assembly that drops to the reactor room floor to prevent melting. If melting occurred, the spray water would keep much of the iodine and particulates from becoming airborne. No credit is taken for this, however, and 50 percent of the iodine and 100 percent of the noble gases available for release are assumed to escape the assembly and become airborne. The iodine that reaches the carbon bed is assumed to be all elemental iodine because of the high air flow and rapid transport of iodine to the carbon beds (Durant et al., 1966). These parameters are also assumed for all accidents described in the following sections.

Core melting during a reloading accident

A criticality resulting from a reloading accident is postulated to cause some melting of the core (Section G.4.1.8). Core damage would be less than 3 percent for this accident. The melting could release fission products into the moderator. For purposes of analysis, it is assumed that 50 percent of the iodine and all the noble gases become airborne. Prior to the accident, the fission products would have decayed for a minimum of 14 hours. To be conservative, no credit is taken for decay prior to the accident.

Core melting during a loss-of-coolant accident (LOCA)

The LOCA is described in detail in Section G.4.1.17. If the worst conceivable D₂O pipe break were to occur, the emergency cooling and confinement systems would control offsite doses well within the 10 CFR 100 reference values, even with failure of a single active component in the emergency cooling system. No more than 1 percent core damage is expected in the worst-case LOCA. This accident is analyzed assuming 1 percent of the core inventory of noble gases and tritium and 0.5 percent of the iodine (50 percent of that available for release from the core) becomes airborne.

G.5.1.2 Release of radioactivity

In the moderator spill accident, tritium is released to the confinement system and then discharged from the 61-meter stack. This is assumed to occur over a 2-hour period. Only a small part of the tritium would actually be released; the rest would remain in solution in the two (225,000-liter and 1.9-million-liter) holding tanks. It is conservatively assumed that about 3 percent of the tritium evaporates.

For the accidents in which assemblies are assumed to melt, the amount of fission products released is proportional to the fraction of the core that melts. Noble gases and iodine are assumed to be released into the process room. Any gases vented to the blanket-gas system would eventually be released into the confinement system. It is estimated that 1 percent of the particulates (fission products, plutonium isotopes, etc.) would be released into the building, and half of that would reach the filters (Cooper and Rusche, 1968; Durant et al., 1966). Some 99.95 percent of the iodine and 99 percent of the remaining particulates would be captured by the activity confinement system. In the event of a dropped assembly, the reactor room spray system could remove much of the airborne iodine (and particulates) and some of the tritium before they left the process room, but this was not considered in the accident analyses.

Following a postulated melting accident, all noble gases are assumed released from the stack. In comparison with other doses, the released solids are considered insignificant (Cooper and Rusche, 1968). Some of the iodine trapped on the carbon bed would be desorbed as the result of the high radiation field generated by the decay of radioactive iodine. The desorption rates, shown in Figure G-3, are used to calculate potential offsite doses as discussed in Section G.5.2.

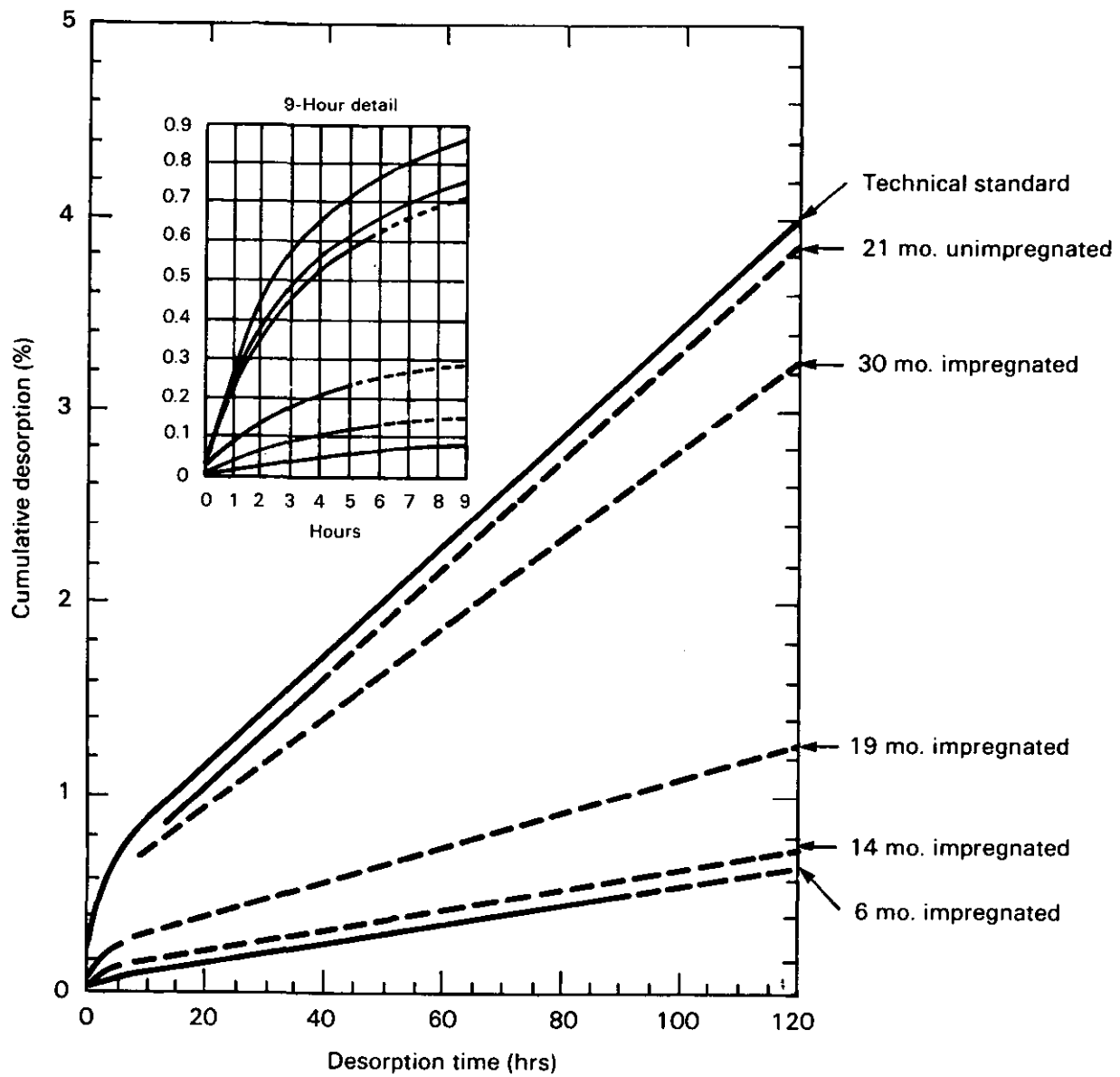
G.5.2 Calculation of offsite dose

This section describes the techniques used to calculate offsite doses resulting from reactor accidents. The calculations and data are consistent with NRC guidelines for accident analysis (NRC, 1972; 1979). The methods discussed were used for analysis of all accidents, including the moderator spill and fuel melting accidents.

G.5.2.1 Dose calculational method and criteria

There are three parameters necessary to compute the offsite doses. First, the radioactive source term must be specified, including the release rate and isotope type. Second, the transport of the isotope to the receptor location by the wind must be computed, based on appropriate calculational models and meteorological data. Third, the external and internal doses to an individual assumed to be at the plant boundary are computed based on parameters of a standard man (including breathing rates) and additional parameters related to absorption of energy from a particular isotope.

Individual characteristics, time of exposure, and meteorological behavior are important variables that are generalized in computing a maximum individual dose. In an actual accident, the WIND computer system of SRP would predict the release path and indicate appropriate action to minimize exposure to people offsite (Garrett et al., 1981). Evacuation procedures, which would reduce the actual dose to an individual, are not considered in these dose calculations (Garrett and Murphy, 1981).



Legend:

- Measured data
- - - Extrapolated (see text)

Figure G-3. Extrapolated radiolytic desorption of iodine from several service aged carbons.

The doses are reported both for 2-hour exposures and for 120-hour exposures. The 120-hour exposure represents a time after which further exposure would not significantly change the overall dose.

The dose calculation uses median meteorology. This and other parts of the calculation are discussed in the following subsections.

G.5.2.2 Source terms for radioactivity releases

The maximum amount of radioactivity available for release following the postulated moderator spill or assembly melting accidents was described in Section G.5.1.

The release from the stack is assumed to propagate over a 2-hour period in one direction as a Gaussian plume, and the exposure of an individual is treated as a time-integrated calculation. This is very conservative because measurements at the SRP site show that the probability of wind persistence for a 2-hour period is, for some directions, only about 20 percent (Langley and Marter, 1973).

The 2-hour irradiation period begins when the radioactive material reaches the Plant boundary. Both the noble gas and iodine source terms are assumed to decay during transport.

The source terms for iodine are the amount that would penetrate (or bypass) the filters and desorb from the charcoal in the first 2 hours and the first 120 hours following the incident. The average iodine retention efficiency assumed for the carbon is that for carbon aged 19 months, typical of normal operation. Carbon beds are replaced on a staggered schedule, so some beds have relatively fresh carbon, some have carbon of intermediate age, and some have carbon approaching its service limit of 30 months.

G.5.2.3 Transport of release and dose calculation

The downwind concentrations of iodine, tritium, and noble gases were calculated according to an integral technique using the computer code NRC145-2 (Pendergast, 1982a,b). This code was developed at Savannah River Plant and uses a Gaussian plume model based on NRC Regulatory Guide 1.145 (1979).

The meteorological data used in the dose calculations were collected from January 1975 through December 1979 (Garrett and Hoel, 1982). The data were obtained at towers near P-, K-, and C-Reactors. Calculations for L-Reactor used data from the closest tower (K-Area). The meteorological data from each tower were averaged for 2-hour periods and sorted into 16 direction sectors, 6 wind speeds, and 7 stability classes. (Stability classes were based on the standard deviation of the mean wind direction).

Median meteorological conditions (50th percentile) were assumed in these calculations. The effects of other less probable meteorological assumptions are shown in Figure 4-9.

Corrections for topography and jet rise of the released plume are applied. The topography correction is prescribed by the regulatory guide (NRC, 1972) and reduces the effective stack height when the downwind terrain is higher than the ground level elevation at the point of release. The jet rise of the plume occurs because the high volume exhaust fans (continuously online) impart a momentum to the gases going up the stack and increase the effective height of the release point. The model for jet rise that is included in NRC145-2 is described in Huber (1981).

The effect of fumigation, a condition that depresses downwind plume elevation to below the release height, was not included. The long distance from the release point to the site boundary makes local fumigation insignificant. Wind shear had no effect on atmospheric mixing at a distance corresponding to the plant boundary.

Interpolation between 2-hour doses and annual average doses was used to obtain the dose for an extended exposure period of 120 hours, using a method recommended in the NRC guidelines, incorporated into NRC145-2 and independently verified (Pendergast, 1982c).

The thyroid dose and the whole-body dose are each composed of an inhalation component from iodine and tritium and a shine component from the gamma emission of the noble gases. The inhalation component was computed by multiplying the isotopic relative concentration by the source strength and dose conversion factors. The shine component integrated the gamma dose from the entire (finite) radioactive plume (Pendergast, 1982a; Cooper, 1972).

G.5.2.4 Dose conversion

The transport of the radioactive release to the plant boundary is calculated using the above techniques. At the boundary the diluted radioactive material is assumed to expose a standard man. To determine the dose received, calculational methods and parameters were used that were consistent with techniques described in Pillinger and Marter (1982). For iodine and tritium, a standard man's breathing rate was used to calculate an inhalation dose. The dose conversion factor considers skin absorption as well as inhalation in the case of tritium.

G.5.3 Results of calculations

The bases and assumptions for both the radioactive source terms and the methods for computing the transport to the plant boundary were described in Sections G.5.1 and G.5.2, respectively. The doses for the four accidents considered are discussed below.

G.5.3.1 Dose from moderator spill

As discussed in Section G.5.1.1.1, this accident considers the tritium dose when moderator is displaced from the reactor (e.g., due to actuation of the ECS). The calculation assumes a release of 0.15 megacurie (about 3 percent of the assumed 5-megacurie tritium inventory in the moderator) over a 2-hour period. The calculated dose to an individual at the plant boundary is shown in Table G-8.

G.5.3.2 Dose from core melting

As discussed in Section G.5.1.1.2, three melting accidents are considered.

G.5.3.2.1 Dose from melting a single assembly during discharge

This accident, discussed in Section G.5.1.1.2, assumes an irradiated fuel assembly, having decayed for 14 hours after shutdown, melts while being discharged. The calculated dose to an individual at the plant boundary is shown in Table G-8.

Table G-8. Calculated radiation dose to a person at the SRP site boundary following four specific accidents (50-percent meteorology and 3000 Mw power)

Accident	Calculated dose (rem)		
	Whole body-2 hr ^a	Thyroid-2 hr	Thyroid-120 hr
D ₂ O spill	0.006	--	--
Discharge mishap (one fuel assembly melts)	0.003	0.004	0.01
Reloading error (about 3% core damage)	0.39	0.51	1.5
LOCA (1% core damage)	0.13	0.17	0.50

^aA 2-hour whole-body dose is essentially the same as the accident-duration whole-body dose.

G.5.3.2.2 Dose from core melting during reloading accident

As discussed in Section G.4.1.8, calculations indicate that the maximum hazard would involve less than 3 percent core damage. It is assumed that the fission product content of the core is the equilibrium concentration that would

be obtained at full power. Even with this assumption, the computed dose at the plant boundary is small relative to the DOE radiation standards for normal operation (see Table G-8).

G.5.3.2.3 Dose from 1 percent core damage during a loss-of-coolant accident

As discussed in Section G.4.1.17, this accident assumes that a massive double-ended pipe break occurs. For conservatism, the break is assumed to be in one of the lines used by the ECS addition system, so that one of the ECS addition systems is incapacitated. It is further assumed that a valve does not open in one of the remaining ECS addition systems. Thus, only one of the three ECS addition systems is assumed to work as designed. The doses (Table G-8) are below the DOE radiation standards for normal operation.

G.5.4 Summary of dose calculations

In summary, the offsite doses listed in Table G-8 were calculated in accordance with accepted methods and assumptions for environmental impact statements (in contrast to the more conservative analyses employed in Safety Analysis Reports). The whole-body and thyroid doses for these postulated accidents are less than the DOE annual radiation protection standards for normal operation. TC

G.5.5 Particulates (both fission product and nonfission product isotopes)

The potential offsite dose from nonfission product isotopes (e.g., cobalt-60, polonium-210, and plutonium-238) that may be present in large quantities in the mixed-lattice charges has also been considered. Few, if any, of these isotopes will be present in sufficient concentrations to generate sufficient heat to melt the target. Hence, major releases of the product materials in mixed-lattice charges would be expected to occur only in conjunction with a major reactor accident.

For calculational purposes, it is assumed that in an accident the fractional release of the nonfission product isotopes to the building environment, transport in the reactor building, and removal by the activity confinement system will be identical to the behavior of particulate fission products discussed in Brown (1971), namely, 1 percent of the inventory in the damaged portion of the core is released to the building, 50 percent of the released fraction is deposited in the building before reaching the activity confinement units, and 99 percent of the remainder is collected by the units. For the maximum credible core damage of 3 percent, the assumed net release fraction from the damaged core portion is thus 5×10^{-5} .

To provide an estimate of the relative magnitude of the potential offsite effects of several isotopes, full-charge inventories of several possible products have been calculated. The core inventory of several typical isotopes is shown in Table G-9. The inventories are based on the production capability in a single reactor (except plutonium-238 inventory, which is based on the availability of intermediates as feed material). Lesser amounts would be present in mixed lattices involving the production of several isotopes simultaneously.

Table G-9. Potential offsite doses from nonfission product isotopes^a (50-percent meteorology)

Isotope	Maximum inventory (megacuries)	Amount inhaled ^b during 2-hour exposure at plant boundary (μCi)	50-year dose commitment (rem)	Critical organ
Co-60	230	2×10^{-1}	1×10^{-1}	Lung
Po-210	38	3×10^{-2}	8×10^{-1}	Lung
U-233	0.0005	3×10^{-7}	2×10^{-5}	Lung
Pu-238	0.45	3×10^{-4}	8×10^{-1}	Bone
Pu-239	0.022	2×10^{-5}	4×10^{-2}	Bone
Cm-244	0.25	2×10^{-4}	1×10^{-1}	Bone

^aThese numbers generally are based on reactor charge producing a single product (the exception is plutonium-238). If two or more products are being produced simultaneously in the same reactor, the maximum inventory of any one would be lower.

^bRelease fraction of 5×10^{-5} for all isotopes.

Values of potential doses from a postulated accident releasing 3 percent of the core inventory were computed for each isotope by multiplying the curies released by the relative concentration (χ/Q) and an appropriate dose conversion factor. The calculation was similar to the inhalation dose calculations described in Section G.5.3. The assumed breathing rate was 3.47×10^{-4} cubic meter per second.

The quantity of each isotope that might be inhaled by a receptor at the plant boundary was calculated using the method described in Section G.5.2. Fallout, deposition, and decay in transit to the plant boundary were neglected. The calculated amount of each isotope inhaled is shown in Column 3 of Table G-9, assuming all of the aerosols reaching the boundary are of respirable size. The fractional release for all isotopes is based on 3 percent damage.

There are no official guidelines related to the inhalation of isotopes in a short time (as in a reactor accident). The dose conversion factors for chronic inhalation (Pillinger and Marter, 1982) were used to compute the potential 50-year dose commitments shown in Table G-9. The most restrictive dose conversion factors were used to determine the critical organ that received the highest dose. Thus the insoluble form of cobalt-60, polonium-210, and uranium-233 was assumed with the lung as the critical organ. The soluble form of plutonium-238, plutonium-239, and curium-244 was assumed with the bone as the critical organ.

The whole-body dose from noble gases present in the fuel in the same reactor charge is not included in Table G-9. The whole-body irradiation from exposure to gamma emitters would be added to the doses received from inhalation of particulates.

G.5.6 Review of Severe LOCA Scenario

A loss-of-coolant-accident (LOCA) is defined as a leak of heavy-water coolant from the reactor's primary cooling system. No fuel melting is expected in any probable LOCA. The rate of leakage in a LOCA could range from a trickle at a flange to a major discharge if a large pipeline should experience a rupture. An emergency cooling system (ECS) is provided to add water to the reactor to cool the core in case such a leak occurs. For conservatism, the ECS design provides sufficient flow to cool the core completely for the most severe leak that can be hypothesized. No reasonable mechanism has been identified that can cause a leak of this magnitude. For smaller, more probable leaks, the ECS would supply coolant far in excess of that needed to cool the core.

The heavy water in the SRP reactors gradually builds up small amounts of radioactive tritium from neutron activation. If part of the tritium evaporates, some would mix with the reactor building atmosphere and pass to the environment via the 61-meter exhaust stack. Assuming conservatively that there is 3 percent of heavy water evaporated and that it contains a maximum tritium content, the maximum dose from exposure to tritium to a person at the Plant boundary would be 0.007 rem.

If the ECS were activated, it would flood the reactor cooling system at a rate of up to 53,000 liters per minute, causing the heavy-water primary coolant to be displaced into sumps from which the heavy water would be pumped into two holding tanks that are vented to the reactor building. The first holding tank has a capacity of 225,000 liters and would retain initially all of the displaced heavy water from the reactor. The second holding tank has a capacity of 1.9 million liters. Following an accident, the ECS flow could be reduced gradually as the leak is isolated and the residual decay power in the reactor decreases. If the leak is isolated promptly, as expected in most cases studied, the holding tanks would not be completely filled. Otherwise, the holding tanks might be filled in a few hours. In the unlikely event that the ECS flow would have to continue beyond the time the holding tanks are filled (2.1-million-liter capacity), the water from the reactor would be river water with little or no tritiated heavy water expected. This water would then bypass the holding tanks and flow to the 190-million-liter excavated basin. Some additional tritium release to the atmosphere might occur; it would, however, be very small.

Even if only one of three ECS supply lines functions properly (i.e., if the LOCA occurred in one of the lines and if valves in a second line failed to open), no melting would be expected for the more credible leak rates. For the hypothetical maximum leak rate, it has been estimated that as much as 1 percent of the core might become overheated and possibly melt in the first minutes of an accident while the decay power is high. In the event of such melting, some radioactive fission products--particulates, volatile noble gases and radioiodine--would be released from the fuel and swept along with the ECS flow. The particulates and soluble radioiodine would be carried to the holding tanks where they would be confined. Noble gases and volatile radioiodine would tend to enter the building or confinement tank and pass into the confinement filter system. More than 99 percent of the radioiodine would be absorbed on the carbon beds provided for that purpose. However, noble gases would be released to the

environment. The estimated radiation exposure to the maximum individual at the plant boundary would be approximately 0.1 rem whole body and 0.5 rem to the thyroid.

As noted above, if ECS flow continues beyond the time at which the 2.1-million-liter tanks are filled, any additional discharge would bypass the holding tanks and enter directly into the 190-million-liter basin. Because possible melting and fission-product release would have occurred early in such a transient, river water entering the earthen basin after the holding tanks were filled would have passed through a well-cooled and well-flushed core. That river water would be expected to carry only a minimal quantity of fission products and other contamination into the earthen basin. No additional risk is attributed to this accident because the metallic fuels used in SRP reactors will resolidify when cooling is restored; there is an extremely low probability of delayed core damage after the ECS flow has been established and the confinement tanks have been filled.

Therefore, no radioactive material, except some tritiated moderator, would be released as a result of any expected LOCA (no melting occurs). For the more severe hypothetical and improbable case of a 1-percent core heatup and melt following a LOCA, most fission products, except noble gases and small amounts of tritium and radioiodine, which could escape from the core, would be contained within the reactor building and the holding tanks.

While there has never been a major accident to challenge the confinement system, the system was developed on the basis of a comprehensive experimental program. Routine performance tests of the confinement system are conducted regularly. Furthermore, when a source rod melt at one of the SRP reactors did challenge the major features of the system in 1969, it responded perfectly. The system is always on line (i.e., ventilation air is continuously drawn through the filters by three fans powered by two independent motors with automatic backup power supplies). Only one operating fan is required.

The confinement system ventilation air first passes through demisters that remove any water droplets, allowing the HEPA and carbon filters to operate at maximum efficiency. The effect of radioiodine overloading causing carbon to overheat has been studied extensively. Even for a maximum loading associated with a theoretical 100-percent core meltdown, the air flow from a single fan is sufficient to keep the carbon from overheating. For the postulated worst hypothetical accident of a 3-percent core melt, the margin on overheating would be much larger.

Because carbon is less effective in absorbing and retaining organic iodide compounds compared to elemental iodine, SRP has developed special impregnants for the carbon used in the confinement system. These impregnants improve the capacity of the system both to absorb and to retain organic iodide. Furthermore, the nuclear power industry is developing a considerable body of evidence that radioiodine released from fuel elements would be largely in nonvolatile forms that would stay dissolved in water or tend to remain inside the reactor vessel and the reactor building. Because of these phenomena, little volatile radioiodine was released to the reactor building during the TMI-2 accident. The Savannah River Laboratory is engaged in a research program to quantify these effects. The conclusion is that no mechanism exists by which a large portion of

the iodine would be converted instantaneously to organic compounds in an accident; the effect of organic radioiodine release through the confinement system is not a significant dose factor. |TE

The potential for steam or hydrogen explosions in an accident has been analyzed; the impact of such explosions on the confinement system has been assessed. For more credible accidents, the amount of fuel damage is so small as to preclude the potential for such explosions. For the more severe hypothetical accidents, the confinement system has the capacity to accommodate the hypothetical gas or energy releases. If hydrogen were formed during an accident, it would be swept from the building by the high ventilation flow of the confinement system before explosive hydrogen concentrations could be reached. This sweepout is in contrast to a closed containment where a buildup of hydrogen gas could threaten the containment integrity in certain hypothesized accidents. The nuclear industry is considering how to deal with this threat. One option being considered, and already adopted in Sweden, is a filtered, vented containment incorporating many of the features of the SRP confinement system.

G.5.7 Improbability of fission product release

As discussed in previous sections, release of fission products to the environment would first require an initiating event to challenge the physical barriers and safety systems provided to prevent such a release, and then a breakdown or failure of these barriers and systems. Such a sequence is improbable. Although probability values are not precisely known for the rare events being considered here, estimates can be made for illustration. Several sequences using estimated or bounding probability values are discussed in this section for two of the accidents analyzed in Section G.4.1. A more complete probabilistic risk assessment study of the entire spectrum of accidents is under way.

G.5.7.1 Hypothetical D₂O pipe break

An abrupt double-ended break of a major D₂O pipe is discussed in Section G.4.1.17. It is not considered to be a credible accident because an abrupt catastrophic failure that allows unimpeded leakage from both sections of pipe is believed to be impossible with stainless steel pipe. However, the frequency of some type of large pipe failure has been previously estimated at 1×10^{-4} to 1×10^{-5} per reactor year. The log mean of this range, 3×10^{-5} , is assumed to be the upper bound of probability of the maximum possible pipe break, which is the initiating event of the sequence shown in Figure G-4. This event challenges the shutdown systems, the Emergency Cooling System (ECS), and possibly the Airborne Activity Confinement System (AACS). The shutdown systems have a very high probability of working, and are excluded as a failure mode in the sequence shown in Figure G-4. The ECS has a high probability of working, which leads to the most probable and least harmful outcome of the sequence, namely, a moderator tritium release, but no fission product release. But the ECS can experience partial or total failure; analysis of ECS failure modes lead to the probabilities shown in Figure G-4. These failure modes lead to less probable but larger releases of fission products. For total failure of ECS, the AACS is

Hypothetical Pipe Break	Emergency Cooling System	Sequence Combined Probability, yr ⁻¹	% Core Inventory Released to Reactor Building
3×10^{-5}	Available 0.97	3×10^{-5}	None
	Single Failure 3×10^{-2}	1×10^{-6}	$\leq 1\%$
	Total Failure 5×10^{-4}	1.5×10^{-8}	100%

Figure G-4. Illustrative sequence of hypothetical double-ended D₂O pipe break.

protected by the Confinement Heat Removal System (CHRS). A probability of failure of 0.5 is assumed for this illustration. The probability of outcomes that lead to larger releases of fission products is extremely small, as shown in Figure G-4.

G.5.7.2 Control rod withdrawal accident

The control rod withdrawal accidents are discussed in Section G.4.1.3. These accidents challenge the shutdown systems and possibly the AACS. The gang rod withdrawal is more challenging but less probable, and the sequence is illustrated in Figure G-5. No such event has occurred in over 115 reactor-years of operation, and this establishes an upper bound of an occurrence, with 95-percent confidence, of 3×10^{-2} per reactor year. The safety rod scram system and the automatic backup shutdown system (ABS-S/C) have a high probability of working, and success of either one leads to an outcome with negligible fission product release. Failure of both systems would lead to an undefined amount of core melting, damage to the reactor structure, and ejection of steam into the process room. Even so, there is a good, but undefined, probability that the AACS would contain most of the iodine (but release noble gases and tritium). The probability of significant or large fission product release is very small, as shown in Figure G-5.

G.5.7.3 Total risk from all postulated reactor accidents

To provide a perspective on the overall accident risk of L-Reactor operation, Figure G-6 is a preliminary total probability curve that presents the annual probability of a resident living at the SRP site boundary receiving more than a certain dose from postulated accidents. These results are based on accident analyses presented in the Safety Analysis Report (Du Pont, 1983a), including less severe accidents at the high end of the probability spectrum and an assumed hypothetical 100-percent core melt at the upper bound of the consequences spectrum. Six different accident initiators were considered. For all the accidents, the most probable outcome is no reactor damage. For the six accidents, only 11 postulated, but highly improbable, sequences resulted in significant amounts of reactor core damage (ranging from 1 percent to 100 percent). These accident sequences were as follows:

1. A loss-of-coolant accident with only one operable ECS.
2. A loss-of-coolant accident with a total failure of the ECS.
3. The withdrawal of a single control rod or a gang of control rods with a failure of both the safety-rod scram and the ABS-SC.
4. Loss of coolant to a single target assembly with a failure of both the safety-rod scram and the ABS-SC.
5. A loss-of-pumping accident with only one operable ECS.

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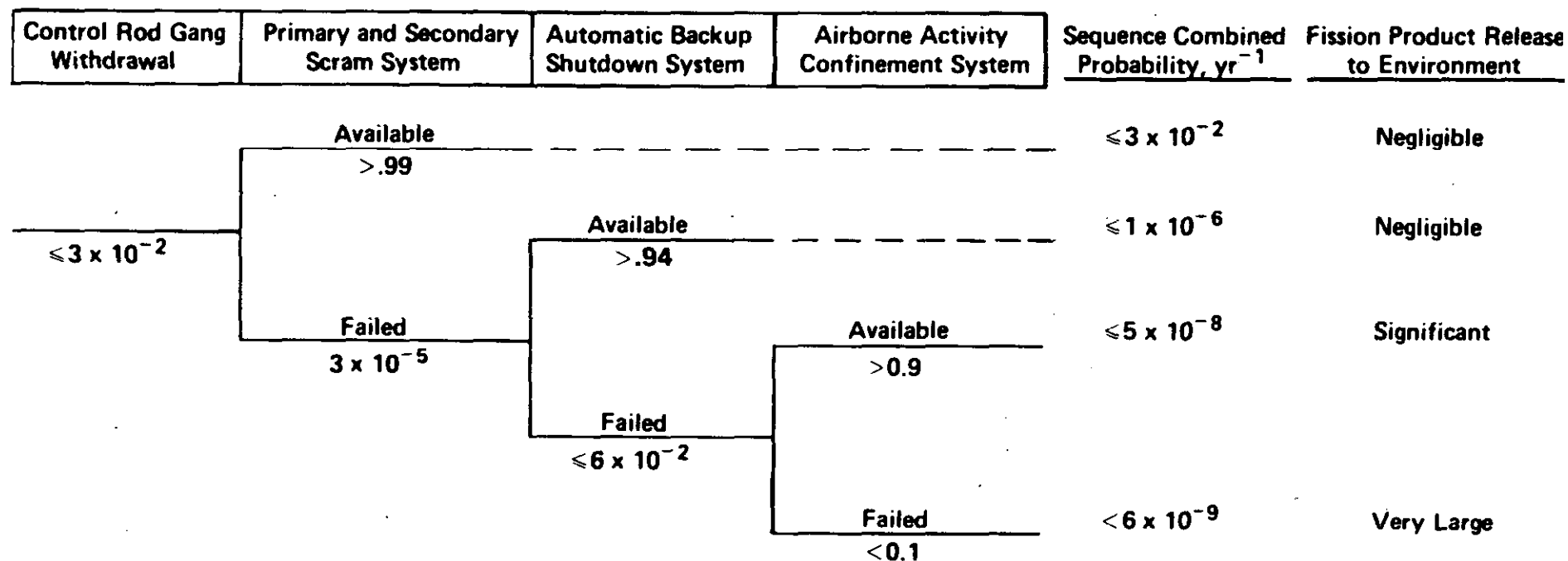


Figure G-5. Illustrative sequence of control rod withdrawal accidents

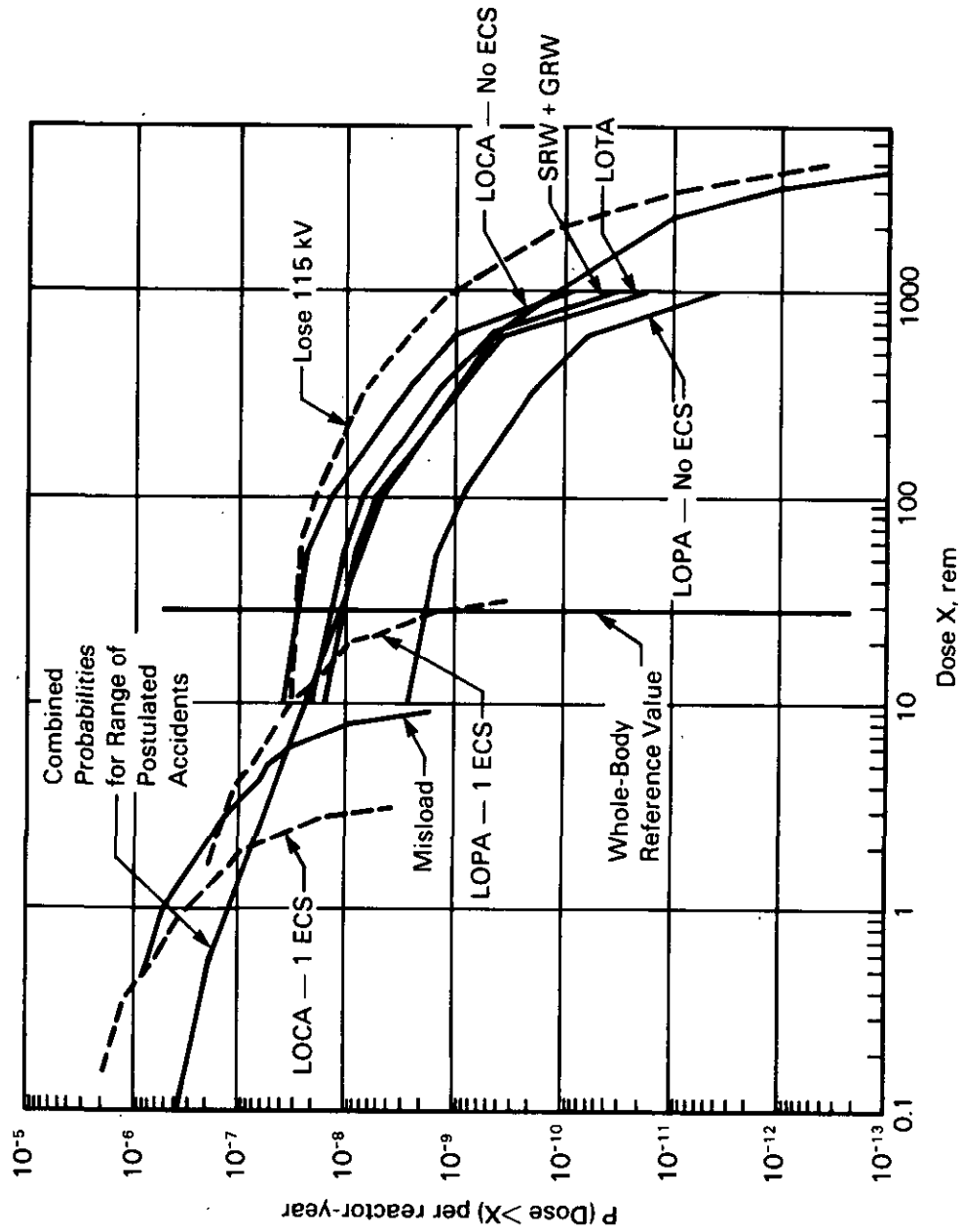


Figure G-6. Total probability (P) per reactor year that the whole body dose to a person on the plant boundary will exceed a specified value, X rem.

6. A loss-of-pumping accident with a total failure of the ECS.
7. A reloading error during charge/discharge operations making the reactor supercritical.
- 8-11. Extended total loss of offsite (commercial) power together with extended loss of onsite generating capability. This sequence affects all reactors and is postulated to result in core damage to 1, 2, 3, or 4 reactors.

The computed offsite doses for the loss-of-coolant accident with 1 percent core damage and the reloading error with 3-percent core damage are listed in Table G-8 for median meteorology (conditions for which the more severe meteorological conditions are not exceeded 50 percent of the time). The relative doses for other meteorological frequencies are shown in Figure G-7. Doses for postulated core damage of 10 and 100 percent are, respectively, 10 and 100 times the dose for 1-percent damage.

The probability of occurrence of an accident sequence was combined with the data for meteorological probability versus offsite dose for each of the above 11 sequences. Then, for a given dose rate, the occurrence probabilities were combined to obtain an overall probability per reactor-year of exceeding a given dose. This overall dose probability curve is shown in Figure G-6. The results are consistent with (1) the decreasing frequency of meteorological conditions that give higher doses for any accident (Figure G-7), and (2) the extremely low probability of accidents occurring with core damage exceeding 3 percent.

The implementation of reactor safety programs has reduced the probability of occurrence of accidents to extremely low levels. Figure G-6 indicates that the probability of exceeding the Nuclear Regulatory Commission site whole body dose criteria for commercial power reactors (10 CFR 100) of 25 rem at the site boundary in accident situations is extremely low (less than 10^{-7} per year), even in the most severe hypothetical accidents.

The traditional approach to SRP reactor safety analysis addressed the consequences for "worst case credible" (and even some "noncredible") accidents based on the single failure criterion. This criterion assumes that the initial accident is compounded by the failure of the single most important active component designed to mitigate the accident. (An active component is one that must change its state to perform its duty; e.g., a valve must be realigned, etc.) The initiation of the accident and the failure of the component were considered without regard to the actual probability of their occurrence.

Results from the preliminary risk evaluation of the eleven accident sequences discussed above support earlier evaluations, made for worst-case scenarios using single failure criteria, which concluded there is negligible risk to public health and safety.

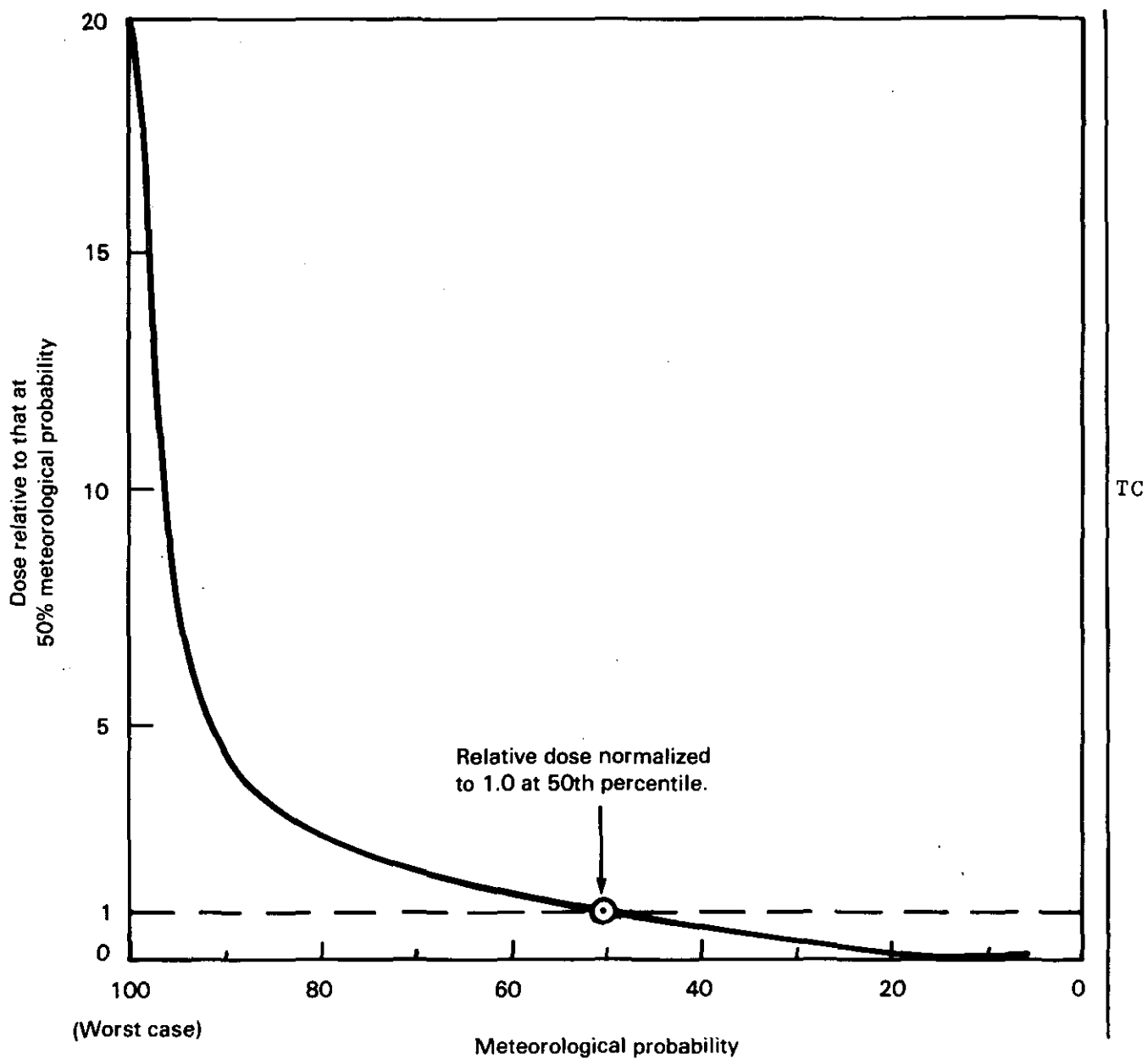


Figure G-7. Approximate effect of meteorology on boundary dose.

G.6 CONSEQUENCE ANALYSIS FOR A 10-PERCENT CORE MELT

Any accident resulting in damage greater than the maximum calculated for the previously discussed accidents (3-percent core melt) is highly improbable. However, in order to assess the consequences of core-melting for which no reasonable mechanistic scenario can be conceived, a 10-percent melt accident (more than three times as severe as the worst accident previously considered) is postulated. Based on the discussion for the lesser consequence accidents, the probability of a 10-percent core melt would be considerably lower than 10^{-6} per reactor year.

The consequence analysis for a 10-percent core-melt accident has been carried out with the CRAC2 code (Ritchie et al., 1981). This is a revised version of the code CRAC (Calculation of Reactor Accident Consequences) which was developed for use in the Reactor Safety Study (NRC, 1975). The organization of CRAC2 is given in Figure G-8.

This section of the appendix summarizes the input data used for CRAC2 analysis. The results of this analysis are presented in Section 4.2.1.5 and summarized in Table 4-24.

Curies of fission products and actinides released to the atmosphere

The amount (curies) of each radionuclide released to the atmosphere for each accident sequence is obtained by multiplying the release fractions by the amounts that would be present in the core at the time of the hypothetical accident.

For a 10-percent core-melt accident, the release fractions are 0.1 for the noble gases, 5×10^{-6} for the particulates and 1.66×10^{-3} for the iodines. Included in the iodine release fraction is the 120-hour desorption from a 30-month service aged carbon filter bed.

The fission product inventory in any SRP reactor charge varies with the reactor charge, the irradiation history, and the operating power level. For purposes of consistency and conservatism, a 3000-megawatt operating power level and saturation inventory of the important fission gases was used. The inventory values were calculated using the Du Pont SHIELD code (Finch, Chandler, and Church, 1979) for single assemblies of both Mark 16 and Mark 31A in the highest power zone of the reactor at the end of the first subcycle. The specific power was 6 megawatts per assembly for the fuel and 2.88 megawatts per assembly for the target. Three hundred assemblies of each type were assumed to obtain a total power of 2664 megawatts. Individual assembly inventory values were then corrected by the factor $(300)(3000)/(2664)$ to obtain full core inventory values for each assembly type. For all short-lived (half-life less than 45 days) isotopes the values thus obtained are saturation inventory values. For long lived isotopes (half-life greater than 225 days), the SHIELD code values for the fuel tubes were multiplied by 5 to obtain the approximate inventory at the end of 5 subcycles. For isotopes with half lives of between 45 and 225 days, the standard buildup decay equations were used to obtain an equilibrium inventory at the end of 5 subcycles. Since targets are not recycled, no correction is necessary for Mark 31A assemblies.

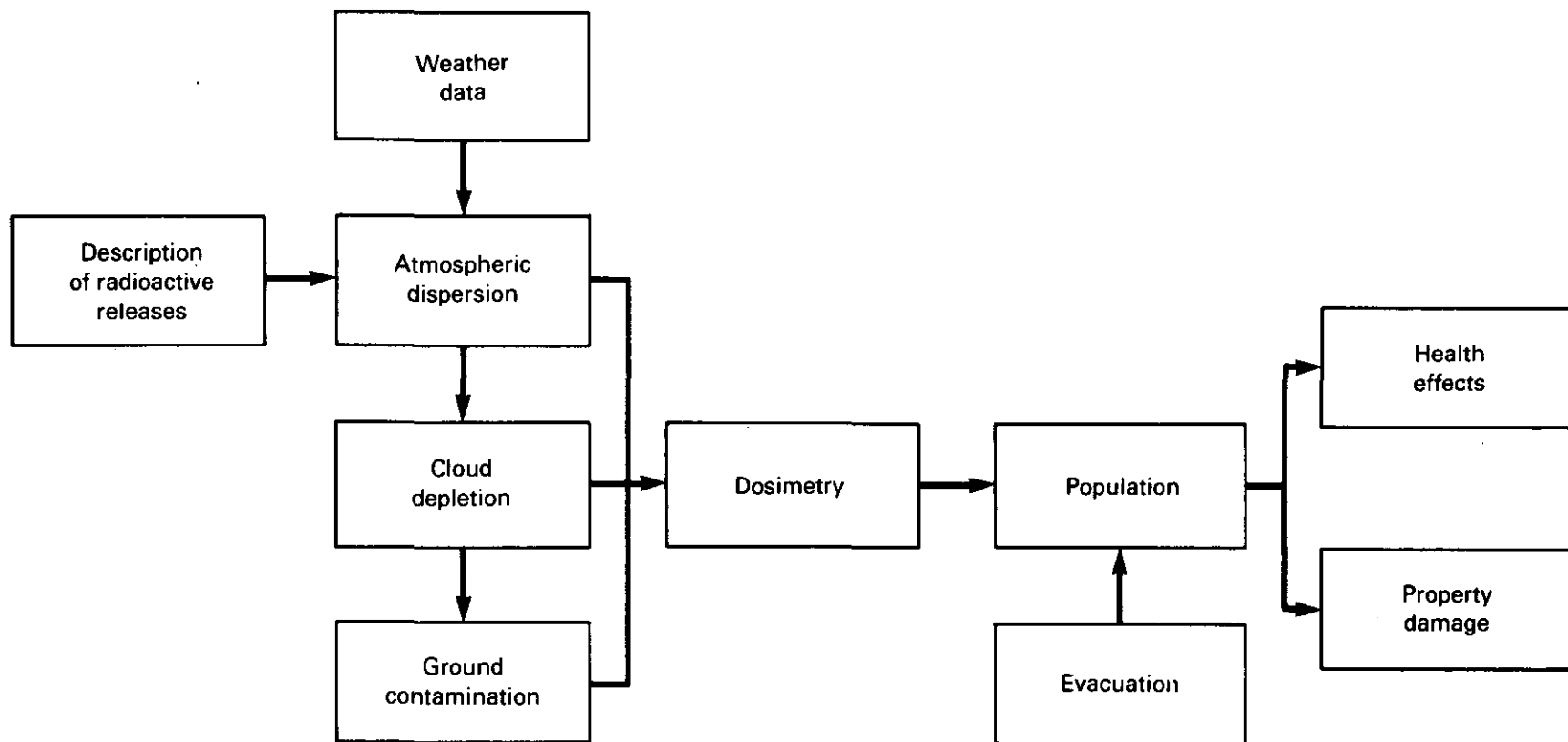


Figure G-8. Schematic outline of consequence model, CRAC2.

The equilibrium isotopic inventory for important radionuclides is tabulated in Table G-10. The radionuclides in this table are the same as those used in the Reactor Safety Study (NRC, 1975). The elimination of radionuclides from consideration in radiation dose calculations was based on a number of parameters, such as quantity (curies), release fractions, radioactive half-life, emitted radiation type and energy, and chemical characteristics.

Meteorological data

The CRAC2 input data file contains a full year of consecutive hourly values of windspeed, wind direction, stability class and precipitation. These were processed from measurements taken at the K-Area meteorological tower during the year 1978. Hourly precipitation data for Augusta, Georgia, was obtained from the National Weather Service. The stability category was determined by using the sigma-theta's from the K-Area meteorological data file.

Prior to sequence selection, the entire year of weather data was sorted into 29 weather categories (termed "bins"), as defined in Table G-11. Each of the 8760 potential sequences was first examined to determine if rain occurs anywhere within 50 kilometers of the accident site. If not, a similar examination was made for wind speed slowdowns. If neither of these conditions occurred, the sequence was categorized by the stability and wind speed at the start of the accident. A probability for each weather bin was estimated from the number of sequences placed in the bin. Sequences were then sampled from each of the bins (with appropriate probabilities) for use in risk calculations, assuring that low probability adverse weather conditions were adequately included (four sequences were selected from each bin in this current analysis). The proposed technique also allowed the use of wind direction statistics for specific weather conditions.

Population distributions

The population distribution around the site has been assigned to a grid consisting of 16 sectors, the first of which is centered on due north, the second on 22-1/2 degrees east of north, and so on. There are also 28 radial intervals as shown in Table G-12, which contains the predicted permanent resident population for the year 2000.

Evacuation modeling and other protective measures

In this assessment, no evacuation and special sheltering measures were assumed.

Other countermeasures

The other protective actions include (1) either complete denial of use (interdiction) or permitting use only at a later time after appropriate decontamination of crops and milk; (2) decontamination of severely contaminated land and property when it is considered to be economically feasible to lower the levels of contamination to protective action guide levels; (3) denial of use (interdiction) of severely contaminated land and property for varying periods of time until the contamination levels are reduced by radioactive decay and weathering to such a level that decontamination is economically possible as in (2) above.

Table G-10. Equilibrium activity in the reactor core

Group/radionuclide	Radioactive inventory (millions of curies)	Half-life (days)
A. <u>Noble Gases</u>		
Krypton-85	0.23	3,919
Krypton-85m	4.8	0.187
Krypton-87	35	0.0528
Krypton-88	73	0.117
Xenon-133	167	5.29
Xenon-135	20	0.382
B. <u>Iodines</u>		
Iodine-131	74	8.04
Iodine-132	114	0.0952
Iodine-133	174	0.867
Iodine-134	181	0.0365
Iodine-135	164	0.274
C. <u>Alkali metals</u>		
Rubidium-86	0.012	18.7
Cesium-134	0.28	752
Cesium-136	0.44	13.0
Cesium-137	1.9	11,000
D. <u>Tellurium-antimony</u>		
Tellurium-127	3.6	0.390
Tellurium-127m	0.31	109
Tellurium-129	5.3	0.049
Tellurium-129m	4.3	33.4
Tellurium-131m	10.3	1.25
Tellurium-132	113	3.25
Antimony-127	4.1	3.80
Antimony-129	18.8	0.181
E. <u>Alkaline earths</u>		
Strontium-89	100	52.0
Strontium-90	0.59	10,260
Strontium-91	136	0.395
Barium-140	145	12.8
F. <u>Cobalt and noble metals</u>		
Cobalt-58	0.0	71.3
Cobalt-60	230	1,921
Molybdenum-99	156	2.75
Technetium-99m	134	0.251
Ruthenium-103	80	39.6
Ruthenium-105	7.8	0.185
Ruthenium-106	4.5	369
Rhodium-105	38	1.48

Table G-10. Equilibrium activity in the reactor core (continued)

Group/radionuclide	Radioactive inventory (millions of curies)	Half-life (days)
G. <u>Rare earths, refractory oxides and transuranics</u>		
Yttrium-90	0.12	2.67
Yttrium-91	118	58.8
Zirconium-95	132	65.5
Zirconium-97	145	0.70
Niobium-95	39	35.1
Lanthanum-140	144	1.68
Cerium-141	135	32.5
Cerium-143	147	1.38
Cerium-144	62	284
Praseodymium-143	132	13.6
Neodymium-147	54	11.0
Neptunium-239	45	2.35
Plutonium-238	0.45	32,510
Plutonium-239	0.022	8.9×10^6
Plutonium-240	0.020	2.5×10^6
Plutonium-241	4.9	5.333
Americium-241	Trace	1.6×10^5
Curium-242	Trace	163
Curium-244	0.25	6,611

Table G-11. One year of SRP meteorological data summarized using CRAC2 weather bin categories

Weather bin ^a	Number of sequences	Percent
1 R (0)	397	4.53
2 R (0-5)	27	.31
3 R (5-10)	86	.98
4 R (10-15)	76	.87
5 R (15-20)	68	.78
6 R (20-25)	58	.66
7 R (25-30)	56	.64
8 S (0-10)	65	.74
9 S (10-15)	46	.53
10 S (15-20)	57	.65
11 S (20-25)	47	.54
12 S (25-30)	50	.57
13 A-C 1,2,3	1609	18.37
14 A-C 4,5	1985	22.66
15 D 1	19	.22
16 D 2	116	1.32
17 D 3	303	3.46
18 D 4	1239	14.14
19 D 5	1016	11.60
20 E 1	8	.09
21 E 2	33	.38
22 E 3	109	1.24
23 E 4	654	7.47
24 E 5	456	5.21
25 F 1	1	.01
26 F 2	0	.00
27 F 3	7	.08
28 F 4	99	1.13
29 F 5	73	.83
30 All	8760	100.0

^aWeather bin definitions: R = rain starting within indicated interval (miles); S = Slow-down occurring within indicated interval (miles); A-C, D, E, F = stability categories; 1(0-1), 2(1-2), 3(2-3), 4(3-5), 5(GT 5) = wind speed intervals (m/s).

Table G-12. 500 mile population around the Savannah River Plant (year 2000)

Sector (miles)	Direction															
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
0-5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5-6	343	0	0	0	0	0	0	0	0	0	0	0	0	594	166	582
6-7	406	0	0	0	0	0	0	0	0	0	0	0	0	702	196	688
7-8.5	725	0	0	0	0	0	0	0	0	0	0	0	0	1,256	350	1,231
8.5-10	866	0	0	0	0	0	0	0	0	0	0	0	0	1,498	418	1,469
10-12.5	744	248	244	1,296	668	1,339	0	136	191	54	195	0	441	681	681	681
12.5-15	910	303	298	1,584	816	1,636	0	166	234	65	238	0	539	832	832	832
15-17.5	1,075	357	352	1,871	964	1,934	0	196	276	78	282	0	636	983	983	983
17.5-20	1,240	412	406	2,159	1,112	2,231	0	226	319	90	325	0	734	1,134	1,134	1,134
20-25	1,534	1,710	2,606	1,058	6,435	1,750	3,213	344	1,354	1,098	1,328	1,514	4,370	85,500	22,545	3,625
25-30	1,876	2,090	3,184	1,292	7,865	2,140	3,927	421	1,656	1,342	1,622	4,296	5,340	104,500	27,555	6,875
30-35	4,829	2,303	4,425	4,332	3,329	1,490	2,776	263	3,622	3,264	961	984	1,416	53,859	3,608	6,175
35-40	5,571	2,657	5,105	4,998	3,841	1,720	3,204	303	4,178	3,766	1,109	1,136	1,634	62,141	4,162	7,125
40-45	15,960	11,569	9,491	24,696	4,207	2,370	5,241	3,329	2,323	1,454	1,180	35,934	6,186	12,183	746	2,153
45-50	17,840	12,931	10,609	27,604	4,703	2,650	5,859	3,721	2,597	1,626	1,320	40,166	6,914	13,617	834	2,407
50-55	6,597	20,006	7,913	3,363	10,196	13,538	950	4,769	2,663	12,436	1,945	6,746	4,359	4,207	0	3,973
55-60	4,049	83,355	1,801	5,692	7,064	7,942	3,877	5,331	2,012	16,314	2,774	6,732	2,259	15,373	1,843	8,114
60-65	4,469	238,810	12,399	7,452	6,781	3,414	1,963	1,774	7,440	8,319	12,828	1,406	2,161	3,883	4,117	3,513
65-70	7,469	71,605	8,754	2,744	9,262	1,175	14,588	9,772	2,419	2,807	2,032	4,121	808	5,073	7,112	2,160
70-85	28,254	32,443	83,105	26,074	46,641	29,868	49,554	149,261	15,174	18,912	14,431	20,134	8,345	13,548	13,176	63,868
85-100	17,848	15,101	50,275	24,691	73,165	307,548	0	81,166	43,624	18,753	28,273	33,616	30,326	18,033	30,880	64,774
100-150	535,167	739,871	242,749	220,574	65,823	17,049	0	0	110,916	130,924	85,650	322,803	155,158	321,599	303,938	627,901
150-200	520,257	569,736	471,232	226,947	0	0	0	0	481,647	94,143	296,543	129,361	661,698	1,997,307	252,347	423,326
200-350	1,544,634	2,353,312	1,898,145	677,017	0	0	0	0	2,992,666	359,816	700,371	1,123,321	1,870,505	1,970,892	1,570,018	1,578,207
350-500	3,981,245	5,776,096	3,376,463	23,776	0	0	0	11,165	5,583,113	461,840	1,343	1,773,316	1,149,501	2,392,794	3,266,522	4,759,461

These actions would reduce the radiological exposure to the people from immediate and/or subsequent use of or living in the contaminated environment. In CRAC2, these protective actions are modeled in the same way as in WASH-1400 (NRC, 1975).

Exposure pathways

The exposure pathways modeled by CRAC2 are the following. First, there is inhalation of radioactive material from the passing cloud. The inhalation dose conversion factors, which relate the curies inhaled to the subsequent radiation dose to various body organs, remain the same as those used in the Reactor Safety Study and are contained in the standard CRAC2 data file. Second, there are cloudshine and groundshine, the irradiation of body organs by gamma rays emitted by the passing cloud or by fission products deposited on the ground. The cloudshine and groundshine dose conversion factors also remain the same as in the Reactor Safety Study and are contained in the CRAC2 data file. Third, there are chronic exposure pathways, which include (1) resuspension of deposited radioactive material by the wind; (2) long-term exposure to gamma rays from deposited fission products, especially cesium, including the effects of weathering; (3) consumption of milk; (4) consumption of milk products; (5) consumption of contaminated vegetation; and (6) consumption of crops contaminated by root uptake. The treatment of these chronic exposure pathways remains precisely the same as in the Reactor Safety Study.

Health effects

In CRAC2, the calculation of the health effects caused by radiation doses delivered to various organs is still handled in virtually the same way as was done in the RSS. The health effects model in CRAC2 is based on the BEIR (1972) report of the National Academy of Sciences.

Economic costs

CRAC2 requires various elements of economic cost. These are generally in the form of a cost per person or a cost per acre, e.g., the cost of evacuating a person or of decontaminating an acre of land. The calculation of many of these costs is described in the Reactor Safety Study, Chapter 12, Appendix VI, where they are presented in 1974 dollars. Some allowance has, therefore, to be made for inflation and the CRAC2 manual contains 1980 values. Table G-13 contains a summary of important parameters. In general, it is three of these that dominate the out-of-plant property damage--the value of residential, business, and public areas; the relocation cost; and the decontamination costs. All other costs, including those for agriculture, are relatively unimportant.

Difference between CRAC and SAR analyses

As mentioned in Section 4.2.1.5, there are several differences between the CRAC2 methodology and those that were used to calculate the doses in Section 4.2.1.4. The most important difference is that CRAC2 considers more radiation dose pathways (e.g., doses from groundshine (from radioactivity deposited on the ground), inhalation of resuspended materials, ingestion of milk, milk products,

Table G-13. Economic input data

Parameter	Value (1980 dollars)	Comment
Decontamination cost for farm areas (for DF of 20)	\$499 per acre	From CRAC2 Manual
Decontamination cost for residential, business and public area (for DF of 20)	\$3349 per person	From CRAC2 Manual
Compensation rate per year for residential, business and public area	\$6305 per person	WASH-1400, Appendix VI, para. 12.4.2.1
Value of residential, business and public areas	\$31,527 per person	From CRAC2 Manual
Relocation cost	\$4,344 per person	From CRAC2 Manual
Annual cost of milk consumption	\$135 per person	From CRAC2 Manual
Annual cost of consumption of non-dairy products	\$685 per person	From CRAC2 Manual
Evacuation cost	\$165 per person	From CRAC2 Manual

and contaminated vegetation). Sensitivity studies show that these additional pathways could contribute an additional 50 percent of the total dose.

Other differences include the following:

- Meteorological data utilization.
- One-year (CRAC2) versus 5-year (SAR) meteorological data period
- Site boundary distances. In the CRAC2 analysis, the site boundary is defined as a radius of 13.7 kilometers. In Section 4.2.1.4, the actual site boundary is used.
- Iodine desorption rates. In the CRAC2 analysis, a 30-month aged iodine filter was assumed (with a 3.3-percent cumulative desorption; in Section 4.2.1.4, a 19-month aged iodine filter was assumed (with a 1.3-percent cumulative desorption).
- Population distribution. The CRAC2 analysis uses a population distribution for the year 2000; Section 4.2.1.4 uses the population distribution for 1980. Furthermore, the population distribution in the CRAC2 analysis extends to 800 kilometers rather than the 80-kilometer distribution used in Section 4.2.1.4.

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APPENDIX H

OFFSITE EMERGENCY PLANNING

H.1 INTRODUCTION

The comprehensive emergency preparedness planning effort for the Savannah River Plant (SRP) and its environs includes the development and maintenance of programs and plans at four levels of responsibility: (1) U.S. Department of Energy - Savannah River Operations Office (DOE-SR) Emergency Management Plans (DOE, 1983a-k); (2) Site-specific Contractor Response Plans (Du Pont, 1981); (3) State Emergency Plans (EPD, 1978; EPD draft; GDOD, 1978); and (4) County Emergency Plans (AEPA, 1982; ACCD, 1982). The basis for the SRP Emergency Response Program is the:

- Development of responsible organizations
- Delineation of procedures
- Identification of facilities
- Development of communications systems
- Commitment of resources
- Training of personnel
- Coordination with other agencies

DOE-SR Emergency Management Plans provide the basis for responses by Department of Energy management to incidents on the Savannah River Plant site, and when necessary, for interfaces with offsite organizations. Site-specific Contractor Response Plans are developed by E. I. du Pont de Nemours and Company, Inc. (Du Pont), the Department of Energy's operating contractor, in accordance with the Emergency Management Plans to implement responses to unusual incidents at the SRP. State Emergency Plans are used by South Carolina and Georgia state governments to respond to all types of emergencies within the states. They include specialized radiological emergency response plans. County plans further implement site-specific response actions defined in state plans.

The definition of a SRP Emergency Planning Zone (EPZ) is required by DOE Order 5500.3 (DOE, 1981e) relative to the evaluation of a worst credible accident. DOE-SR has bounded this accident as having a probability of occurrence equal to or greater than 10^{-6} per year for the site (Du Pont, 1983). Use of the probability of 10^{-6} per reactor-year as a threshold for reactor accidents has no absolute statistical basis, but it is consistent with normal practice in the nuclear power industry. The concept, used in this way, states that beyond this threshold, judgmentally, it is reasonable to regard the probability of an accident to be effectively zero, even though it might be unprovable, in a strictly physical sense, that the accident cannot occur. For example, this value can be derived from both an American National Standards Institute (ANSI) standard and the U.S. Nuclear Regulatory Commission Standard Review Plan. ANSI/ANS-212-1978, Appendix B, uses the value of 10^{-6} per site per year as a cutoff probability, below which combinations of events leading to accidents need not be considered for design purposes. The cutoff value does not include the probability of the consequences exceeding 10 CFR 100 dose guidelines, which is included in the NRC Standard Review Plan (NUREG-0800) acceptance criteria of 10^{-7} per year. The use of the 10^{-6} per site per year value in the ANSI standard for accident probability is consistent with the NRC Standard Review Plan's value

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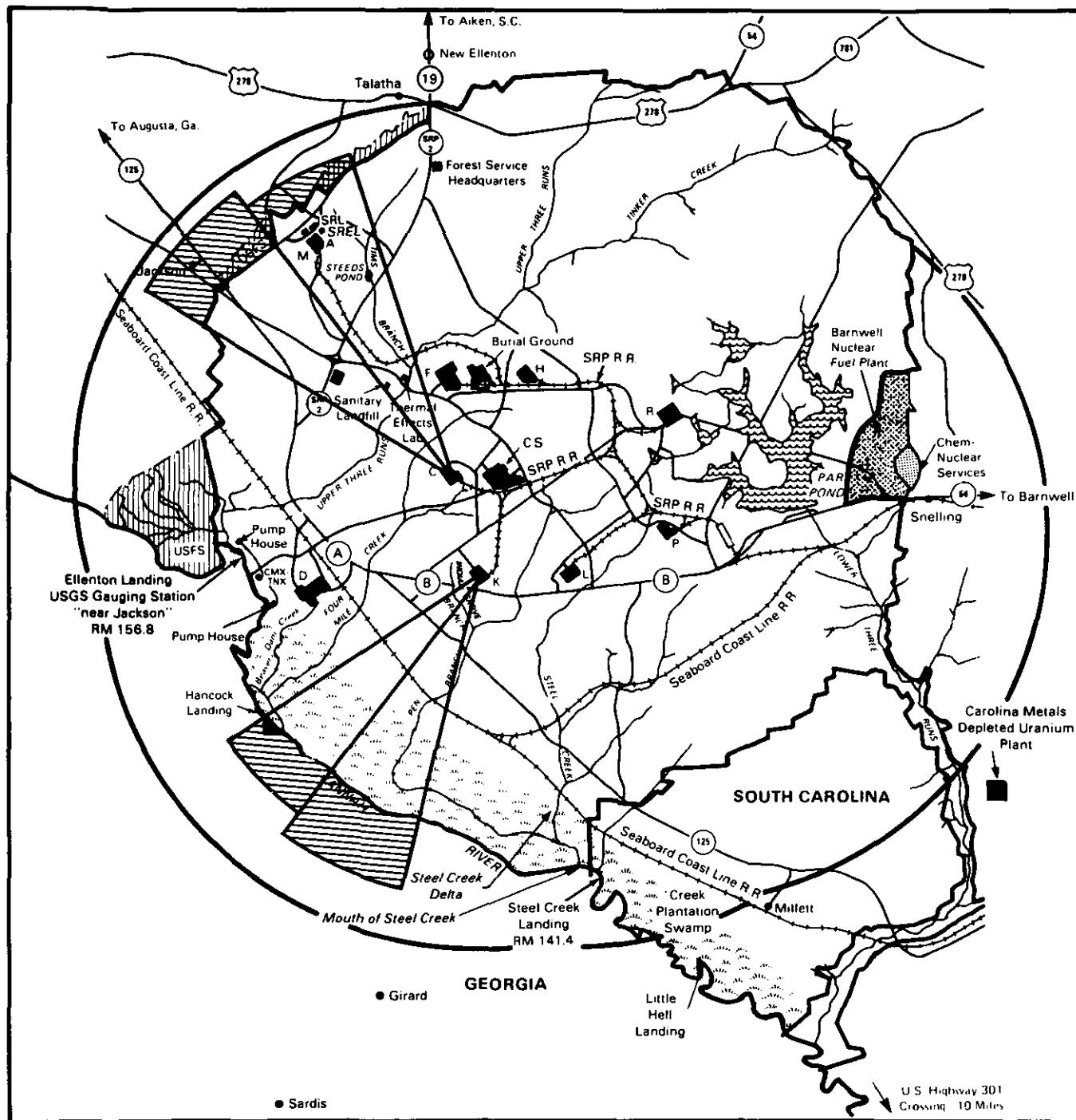
of 10^{-7} per site per year for accident plus consequence probability because the probability of the consequences exceeding 10 CFR 100 dose guidelines following an accident are conservatively estimated to be less than 10^{-1} . The SRP use of the 10^{-6} threshold is not for a so-called "uncontrolled" release, but for separating "treated-as-credible" from "treated-as-noncredible" accidents. Even with estimates of accident probabilities beyond the 10^{-6} per reactor-year threshold, radioactive releases are limited by performance of the reactor confinement system; they are not uncontrolled releases to the environment. The zone boundary is defined by calculated doses that exceed potential dose levels above 5 rem total body or 25 rem to an individual organ (EPA, 1975). A review of the fuels separation facilities Safety Analysis Reports (SAR) revealed that site boundary doses for the spectrum of postulated process accidents were all far below the 5 rem whole-body and 25 rem individual-organ criteria. A spectrum of events including fire, criticality, equipment failures, and natural disasters was considered. The maximum dose calculated at the SRP boundary from any of these incidents was about 0.12 rem to the whole body and about 8.5 rem to the lung from uranium.

TC

For the reactors, the worst accident for which it has been possible to assign a credible mechanism is a reloading accident, in which a series of faults and errors lead to a double target vacancy at the periphery of the reactor, causing a criticality. The probability of this accident ranges from 1.6×10^{-5} to about 1.6×10^{-6} per site-year, depending on whether credit is taken for protection provided by the recently installed charge/discharge computer system (discussed in Section 4.2.1.4); the consequence is that about 3 percent of the reactor core would melt. The release from the melted fuel assemblies is conservatively estimated to be equivalent to about 3 percent of the equilibrium fission product inventory of an operating reactor. This accident, evaluated for each reactor, is the bounding case for establishing the EPZ. The doses from this accident were calculated for each 22.5° sector around each reactor, and isodose boundaries were drawn. The calculations were performed in a manner consistent with the revised Safety Analysis Report; that is, for "worst case" meteorology that is exceeded only 0.5 percent of the time in each wind direction sector. This zone is defined by calculation of the gaseous plume (airborne release) exposure pathway doses wherein the principal exposure sources are: (1) total-body external exposure to gamma radiation from the plume and radioactive materials deposited on the ground, and (2) inhalation exposures from the passing radioactive plume. For this accident, the isodose line for the 25-rem thyroid dose remains within the Plant boundary. However, the 5-rem total-body isodose line extends as far as 2.9 kilometers beyond the Plant boundary in the northwest and southwest directions, as shown in Table H-1 and Figure H-1. The calculations were done individually for P-, K-, L-, and C-Reactors. The table shows the sectors in which the 5-rem boundary extends off the site and the contributing reactor. L-Reactor does not contribute to the offsite EPZ.

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The EPZ defines the area where provisions for immediate response actions are required. It also defines the area for detailed pathway analysis, predictions, monitoring, and radiological assessments. A larger planning zone has been defined for evaluation of potential exposures from the ingestion pathway (food and water), and is shown in Figure H-2. The zone covers an area with an 80-kilometer radius about the center of the SRP, a corridor 2 kilometers wide centered on the Savannah River from the SRP to the Atlantic Ocean and an area encompassing Savannah, Georgia, Beaufort, South Carolina, and the Savannah River Delta. Planning for this zone includes consideration of potential radioactive



Legend:

- Preliminary Emergency Planning Zone (from maximum credible accident analysis)
- Preliminary Contingency Planning Zone (16-kilometer radius about each operating reactor)

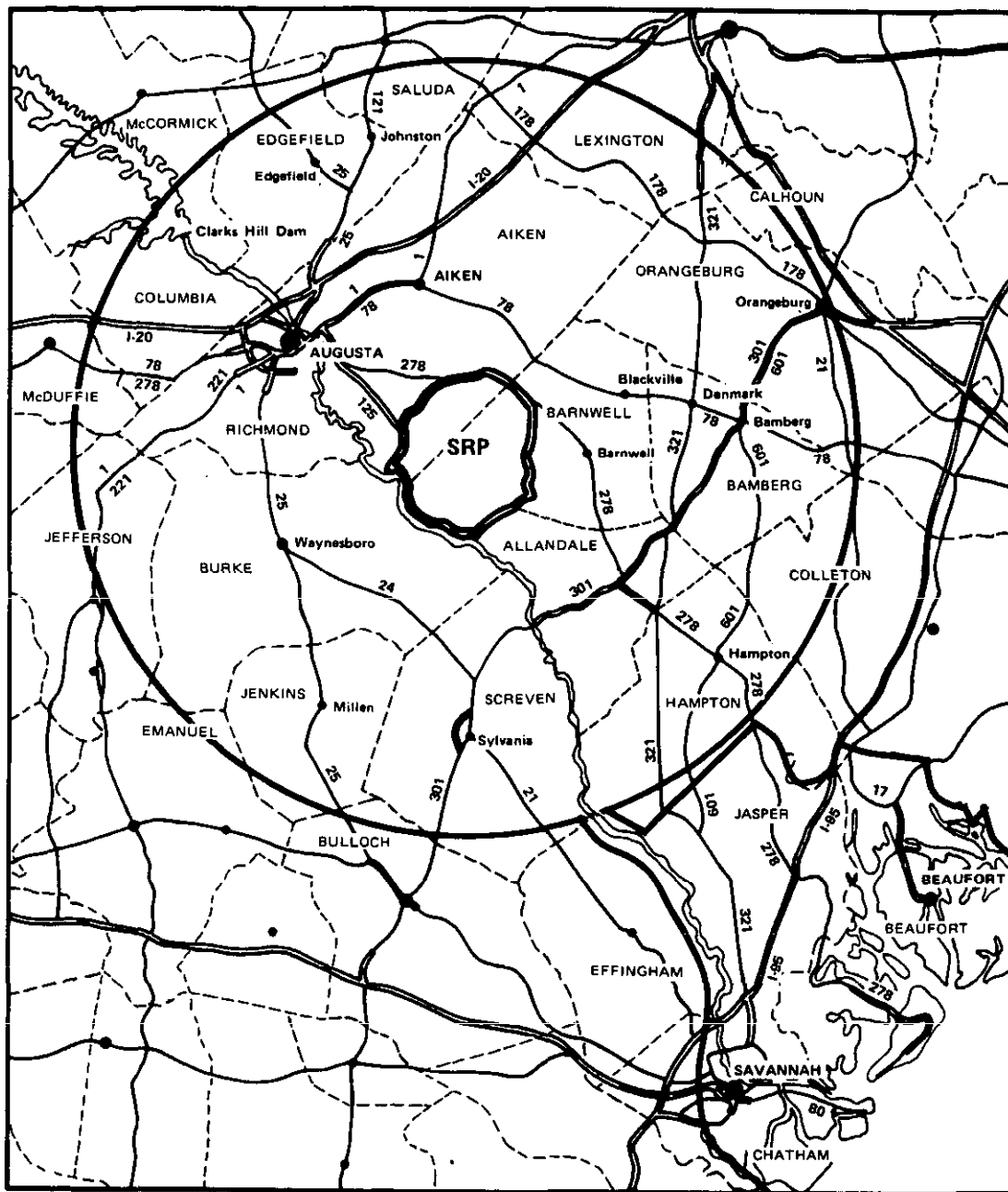
Source: DuPont, 1983.

0 5 10 15 kilometers



Figure H-1. Emergency Planning Zone for the Savannah River Plant.

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Legend:

- Major roads
- - - County lines
- Cities/towns

0 10 20 30 40 Kilometers



Figure H-2. Ingestion Emergency Planning Zone for Savannah River Plant

Table H-1. Dose calculation results for reactor reload accident^{a,b,c}

Reactor	Sector	Distance to 5 rem boundary, miles	Distance to plant boundary, miles	Whole-body dose at plant boundary, rem
C	NW	9.0	7.6	6.0
	NNW	8.3	8.2	5.2
K	SSW	8.5	6.7	7.0
	SW	7.8	6.6	5.4

^aSource: Du Pont, 1983.

^b3% inventory release.

^c99.5% meteorology, worst sector.

materials deposited on ground and water surfaces that might be incorporated into food and water sources. No immediate responses are necessary in this zone, but monitoring and assessments are prudent to control or avoid internal doses from ingestion of contaminated foods (both terrestrial and aquatic) or water.

Beyond the EPZ, DOE has established a Contingency Planning Zone (CPZ) with a 10-mile radius around each reactor. In the CPZ, DOE will provide information and education about SRP operations and notification of incidents. In this area, calculated doses are less than those required by DOE for the EPZ; therefore, immediate warnings and population protective actions are not required. Within this zone, Georgia and South Carolina State guidelines indicate that an additional level of planning is appropriate to provide mechanisms for population sheltering and possible evacuation. In addition, estimates of reactor accident probabilities and consequences change with time as new operating data are added, understanding of processes improves, and process and equipment changes are made. For example, the probabilistic risk assessment (PRA) that has been initiated for SRP reactors might provide more accurate estimates of reactor accident risks, and the DOE establishment of EPZs in cooperation with South Carolina and Georgia officials should make allowances for variations in calculational analyses. The establishment of a Contingency Planning Zone accounts for these variations. Though potential doses in this area are expected to be less than those that require evacuation, and no other immediate protective actions are anticipated, this zone defines an area where DOE-SR and state and local authorities will agree on exactly what kinds of notification and responses are appropriate for SRP incidents.

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The Department of Energy informs the States of South Carolina and Georgia promptly of all incidents that have potential offsite consequences in excess of those stipulated in 10 CFR 20 (NRC, 1964) (the limits in 10 CFR 20 are not requirements but are used by DOE-SR for comparability). However, offsite emergency responses are not implemented unless an unplanned event could have radiological consequences above preset limits and for which protective actions might

have to be implemented. These preset limits and their corresponding incident classification are as follows (DOE, 1983²):

1. Unusual event. An event in progress or having occurred which normally would not constitute an emergency but which indicates a potential exists for possible significant offsite release of radioactive material. Activation of offsite response organizations is not expected. Emergency response actions are limited to onsite areas.

NOTIFICATION LEVEL*

Release or release potential with
projected offsite whole-body doses

≥ 2 mrem in any one hour or;

≥ 0.1 rem in any 7 consecutive
days or;

≥ 0.5 rem in any period of one
calendar year.

or

Airborne or waterborne radioactivity
concentrations released offsite

≥ 10 CFR 20, Appendix B
Table 2 > 24 hr.

NOTIFICATION TIME

States will be notified as soon as
practicable on discovery of an event
but no later than 1 hour after
discovery.

≤ 1 hr.

2. Alert. An event in progress or having occurred which involves an actual or potential substantial reduction of the level of nuclear safety of the facility. Limited offsite releases of radioactive material may occur. The purpose of an alert level is to assure that onsite and offsite emergency response personnel are properly advised and available for activation if the situation becomes more serious, to initiate and perform confirmatory radiation monitoring as required, and to assure appropriate notification of emergency conditions to the responsible organizations within DOE.

NOTIFICATION LEVEL

Release or release potential

≤ 10 Ci I-131 equivalent or;
 $\leq 10^4$ Ci Xe-133 equivalent.

or

*10 CFR 20.105 and .106 (10 FR 14434, October 20, 1964)

Releases with projected offsite dose

$\geq .5 \text{ rem} < 1 \text{ rem}$ whole-body, or;
 $\geq 1.5 \text{ rem} < 5 \text{ rem}$ thyroid.

NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 30 minutes after discovery.

$\leq 30 \text{ min.}$

3. Site emergency. An event in progress or having occurred which involves actual or likely major failures of facility functions which are needed for the protection of onsite personnel, the public health and safety, and the environment. Releases offsite of radioactive material, as identified below, are likely or are occurring. The purpose of the site emergency designation is to assure that appropriate monitoring teams are dispatched, personnel required for determining onsite protective measures are at duty stations, predetermined protective measures for onsite personnel are identified and to provide current information to DOE and consultation with offsite officials and organizations.

NOTIFICATION LEVEL

Release or release potential

$> 10 < 10^3 \text{ Ci I-131}$ equivalent or
 $\geq 10^4 < 10^6 \text{ Ci Xe-133}$ equivalent.

or

Release with projected offsite dose

$> 1 \text{ rem} < 5 \text{ rem}$ whole body, or;
 $\geq 5 \text{ rem} < 25 \text{ rem}$ thyroid.

NOTIFICATION TIME

States will be notified as soon as practicable on discovery of an event but no later than 30 minutes after discovery.

$\leq 30 \text{ min.}$

4. General emergency. An event in progress or having occurred which involves actual or imminent substantial reduction of facility safety. Releases offsite are occurring or are expected to occur and exceed the levels identified below. The purpose of the general emergency level is to initiate predetermined protective actions for onsite personnel, the public health and safety, and the environment, provide continuous assessment of emergency conditions and exchange of information both on-site and offsite. Declaration of a general emergency will initiate major activation of DOE-wide resources required to effectively mitigate the consequences of emergency conditions and assure the protection of onsite personnel, the public health and safety, and the environment to the extent possible.

NOTIFICATION LEVEL

Release or release potential

$\geq 10^3$ Ci I-131 equivalent or;
 $\geq 10^6$ Ci Xe-133 equivalent.

or

Releases with projected offsite
dose

≥ 5 rem whole body, or;
 ≥ 25 rem thyroid.

NOTIFICATION TIME

States will be notified as soon
as practicable on discovery of an
event but no later than 30 minutes
after discovery.

≤ 30 min.

Should the initial assessment indicate that the incident falls below classification guidelines outlined above (e.g., of minor consequence to the public health and safety), DOE will make additional evaluations to further determine the need for notification of offsite authorities. Considerations in this determination will include an assessment of the potential/actual level of news media and/or public interest resulting from the incident. Prompt notifications will be made, to the extent practical, prior to issuance of a formal "News Release" or if a significant number of inquiries concerning the incident are received from the media or general public.

TC The development of emergency response plans for SRP is based on (1) the quantity of radioactive material released, or (2) the projected offsite doses from operational releases, as shown in the classifications above. However, the mechanism causing the release does not govern the protective actions implemented. Therefore, emergency response plans are valid for all releases caused by (1) natural phenomena (e.g., earthquakes or tornados), (2) equipment failures (e.g., power outages or broken pipes), (3) procedural errors (e.g., misloading or valve closings), or (4) deliberate actions (e.g., sabotage or terrorist attacks). The offsite response to the released radioactivity is the same. The onsite safeguards and security responses would be different if the cause is identified as a deliberate action. Emergency responses to acts of war also would mobilize the same resources used for general emergencies, with the addition of higher level coordination and the involvement of regional military units. However, specific planning for acts of war on the SRP are not included in these plans.

Emergency plans for the EPZ and CPZ require cooperation, coordination, and integration of resources and responses of the state agencies of South Carolina and Georgia and the county agencies of Aiken, Allendale, and Barnwell in South Carolina, and Burke in Georgia. State and county agencies are responsible for developing and implementing emergency plans for their respective jurisdictions. The Department of Energy is responsible for developing and implementing plans for the plant site. They are also responsible for interfacing with other Federal agencies, local industries, and state and county agencies to define potential incidents, potential consequences of releases, and required resources,

and to ensure that response plans and actions are fully integrated to meet potential needs.

Memoranda of Understanding (MOU) between the States of South Carolina and Georgia and the DOE relative to general responsibilities for notification and emergency response to incidents or potential incidents at SRP were established in August 1974 under the DOE predecessor, the Atomic Energy Commission. These memoranda were renegotiated between the States and DOE-SR, December 1978, and November 1979, respectively (DOE, 1978; DOE, 1979). The current list of agencies and organizations to be notified is:

<u>Always required</u>	<u>Only when necessary</u>	<u>Only for general emergency</u>
DOE-HQ	South Carolina Governor's Office	Aiken County, SC
South Carolina Department of Health and Environmental Control	Georgia Governor's Office	Barnwell County, SC
South Carolina Emergency Preparedness Division	U.S. Army Corps of Engineers	Allendale County, SC
Georgia Department of Natural Resources	Federal Aviation Administration	Burke County, GA
Georgia Emergency Management Agency	Fort Gordon	Richmond County, GA
	Federal Emergency Management Agency	
	Fort Jackson	
	Chem-Nuclear Services, Inc.	
	Seaboard Coast Line Railroad	
	Vogtle Power Plant	
	Allied General Nuclear Services	

The plans outlined in this appendix meet requirements set forth by Department of Energy Orders (DOE, 1981a-f; 1983o) and reflect Department of Energy guidance for offsite planning.

H.2 EXISTING EMERGENCY PLAN

The Department of Energy, the States of South Carolina and Georgia, and the Counties of Aiken, Allendale, Barnwell, and Burke have designated persons responsible for emergency preparedness and have developed various forms of emergency plans. Since portions of the EPZ and CPZ lie outside of the SRP boundary, and within these jurisdictions, response plans are being developed with full cooperation of DOE and state and county agencies. Integration of technical expertise and other resources of responsible agencies is necessary in the development of effective response action plans. General program requirements also include drills and exercises to address various potential emergencies including the Savannah River Plant. The present status of plans is detailed in the following sections.

H.2.1 DOE-SR emergency management plans

The DOE-SR is developing a set of 11 Emergency Management Plans for managing emergencies on and off the SRP (DOE, 1983a-k). These plans are listed in Table H-2, along with their general content and status. Each plan addresses the:

- Purpose
- Jurisdiction and authority
- Policy
- Scope
- Organization
- Responsibilities
- Operations

for the activities and responses defined by the plan as well as appendices and annexes to delineate details, definitions, logic, procedures, and checklists for responsible agencies and individuals. These plans include actions to be taken by the Department of Energy and appropriate coordination by designated state and county officials. They are expected to provide information and guidance concerning incidents at the Plant and the use of resources to disseminate and/or take action. Details of organization, responsibilities, and operations are given in each plan. DOE-SR Emergency Management Plans will be submitted to DOE-HQ for review and concurrence before their formal adoption. The DOE-SR Office of External Affairs (OEA) is responsible for developing and implementing all emergency plans for the SRP.

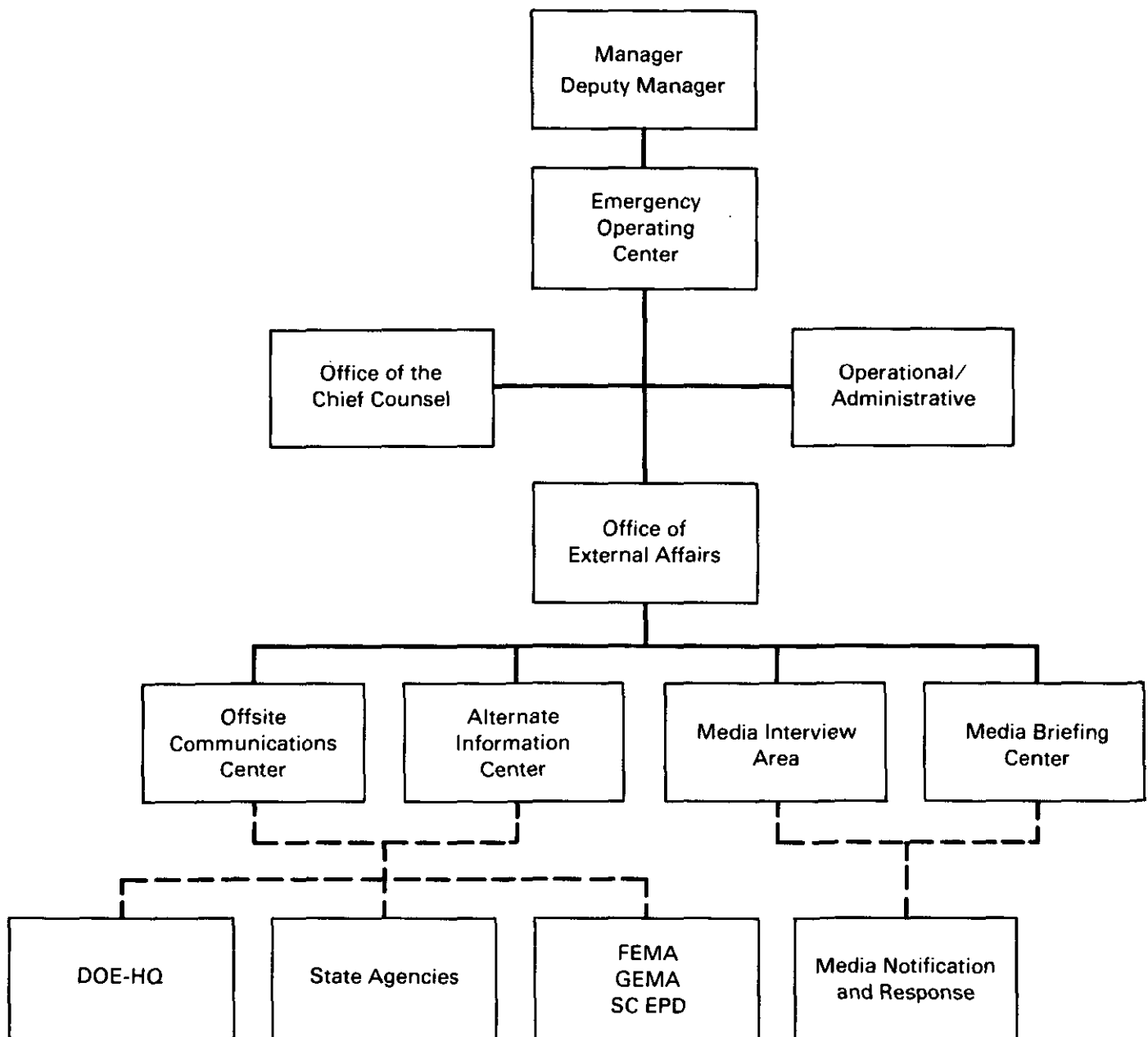
TC | To provide examples of the general content of these plans, the following discussions are provided from the Emergency Public Information Plan (EPIP), SR306 (DOE, 1983e) and the Onsite Radiological Emergency Response Plan, SR402 (DOE, 1983f). Figure H-3 shows the lines of communication and coordination for the plan. Figure H-4 shows the steps to be followed to make decisions and take actions relative to preparing statements, issuing news releases and operating information centers. In addition to the overview logic, the plan provides sublogic networks for each activity step (circles) so that directions at the most detailed level are available.

Figure H-4 provides a summary of the sequence of events, decisions and the consequent flow of information that results from an SRP incident. Beginning with (1) a declared emergency, (2) the activation of the Emergency Operations Center (EOC), and (3) a need to implement EPIP, the overview logic diagram outlines the activities that follow:

- OEA initial response OEA determines whether or not an initial response is required, and if so, provides the necessary response. After analyzing data provided upon arrival at the EOC, OEA advises the DOE-HQ Press Secretary and assesses the public information impacts of the incident.
- Assessment preparatory to a statement or news release OEA prepares a statement for the media and determines the associated onsite and offsite impacts. Based upon the determined response level, OEA assesses the impacts of the incident on the Congress, DOE-HQ, other Federal agencies, state and local governments, industry, and the media, as well as other organizations.

Table H-2. Emergency Management Plans for the Savannah River Plant
(DOE, 1983a-k)

SR 101	<u>Comprehensive Emergency Preparedness and Response Plan</u> - provides the overall, integrated organization and operations of the DOE-SR Emergency Management Program.
SR 201	<u>Duty Officer Procedures</u> - delineates the responsibilities and actions of the DOE-SR Operations Duty Officer relative to plant emergencies.
SR 202	<u>Emergency Management Team Plan</u> - provides for a comprehensive response to any accident that is not a health and safety problem but is or may be of high interest, to governmental authorities or the general public.
SR 302	<u>Offsite Notification Plan</u> - provides a classification and procedure for defining onsite incidents and notifying designated offsite agencies of the potential consequences.
SR 306	<u>Emergency Public Information Plan</u> - provides for a comprehensive response and sustained information dissemination capability for a wide range of incidents to satisfy offsite interests and inquiries.
SR 402	<u>Onsite Radiological Emergency Response Plan</u> - provides procedures and resource responsibilities for onsite responses to potential radiological consequences.
SR 403	<u>Nonradiological Hazardous Substances Spill or Release Response Plan</u> - provides for an effective level of response to a broad scope of unplanned spills or releases of nonradiological substances. It also addresses communication and coordination with state response agencies.
SR 405	<u>Bomb Threat Response Plan</u> - provides for an effective level of response to bomb threats and discovery of suspicious devices.
SR 501	<u>Weapons Incident/Accident Response Group Support Plan</u> - provides the procedures for interim response to an incident or accident involving a nuclear weapon, until the DOE Region 3 Accident Support Group assumes their responsibilities. It also provides necessary interface with state and local agencies.
SR 502	<u>Radiological Assistance Program Plan</u> - provides the response for requests to assist with respect to radiological incidents outside of SRP but within DOE-Region 3. The Radiological Assistance Team advises the onscene authorities on measures to contain and eliminate radiological emergency situations.
SR 602	<u>Emergency Preparedness Appraisal Program</u> - provides the necessary coordination and direction to ensure adequate response capabilities. It provides for evaluation of the level of emergency preparedness.

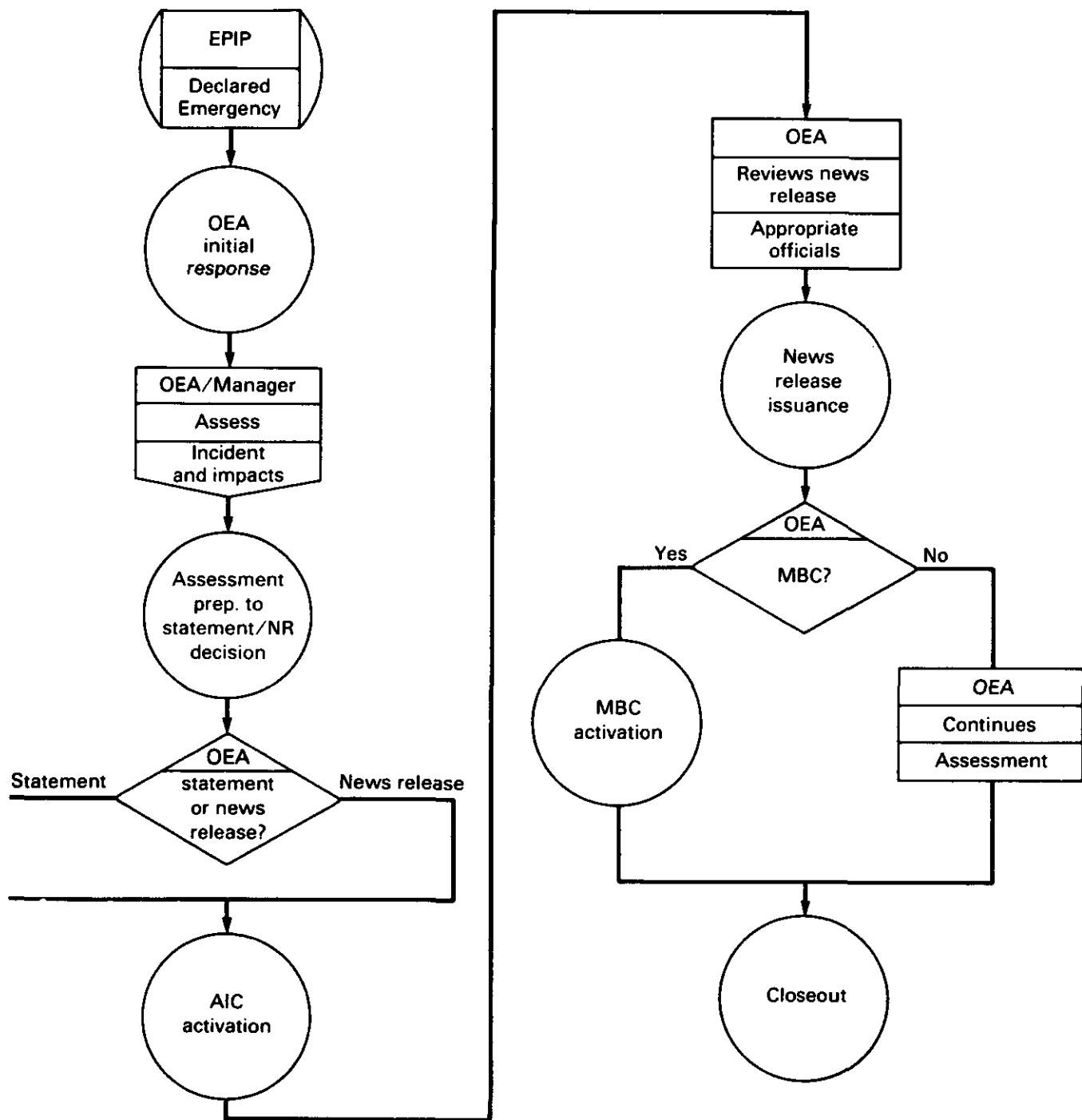


Legend:

- Internal SRP information flow
- - - - External SRP information flow
- FEMA — Federal Emergency Management Agency
- GEMA — Georgia Emergency Management Agency
- SC-EPD — South Carolina Emergency Preparedness Division
- DOE-HQ — Department of Energy Headquarters

Source: DOE, (1993e).

Figure H-3. Lines of communication and coordination for the Emergency Public Information Plan.



Source: DOE (1983e).

Legend:

EPIP — Emergency Public Information Plan
 OEA — DOE-SR Office of External Affairs
 NR — News Release
 AIC — Alternate Information Center
 MBC — Media Briefing Center

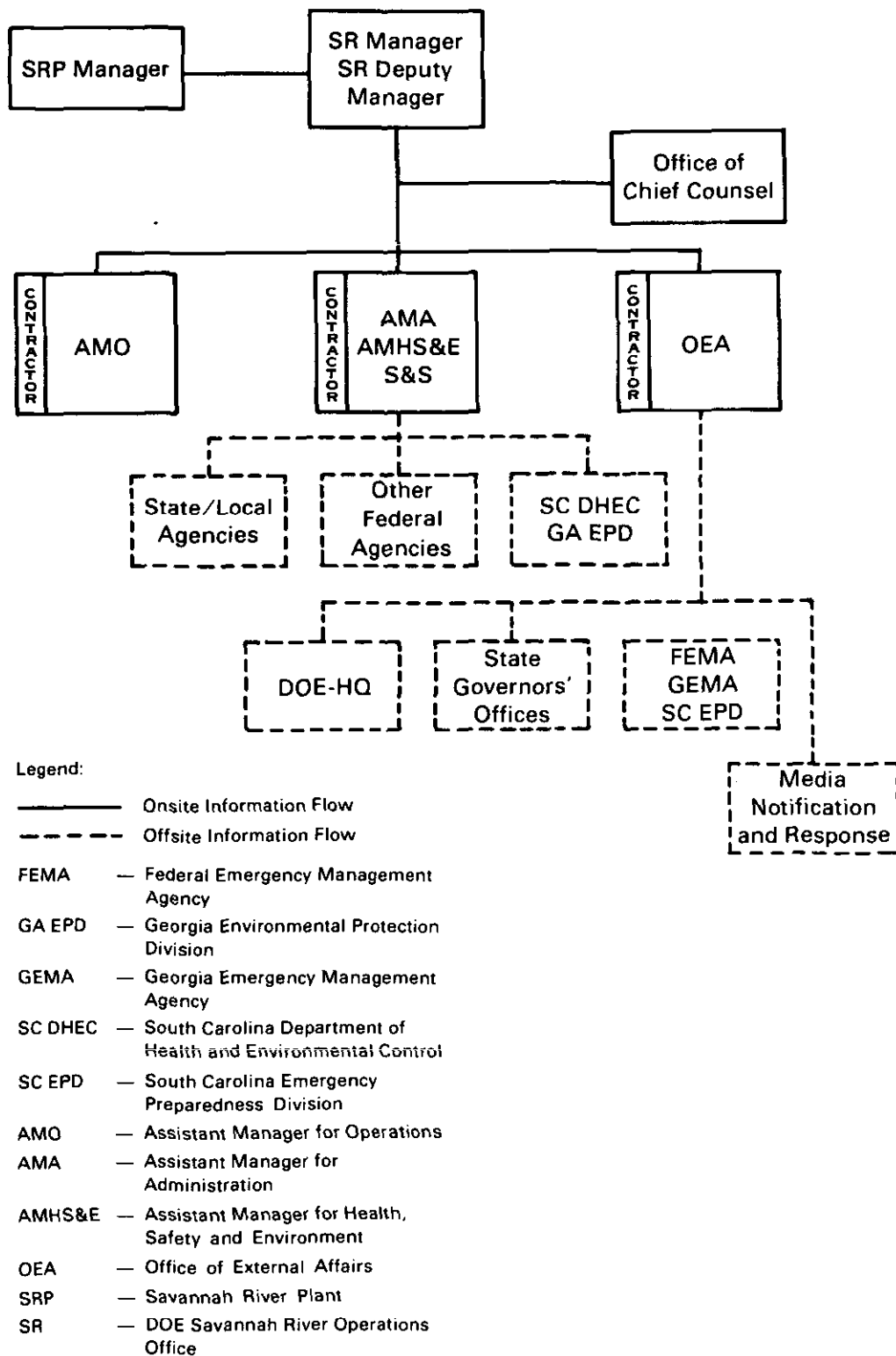
Figure H-4. Overview logic of the Emergency Public Information Plan.

- Alternate Information Center (AIC) activation Based upon the offsite notifications to be prepared (see notification classification in Section H.1 Introduction), the scope of the response, and current incident status information, OEA prepares the appropriate news release or statement and submits it to the Manager for his approval. The AIC is activated as needed. If additional public affairs support is required, OEA notifies DOE-HQ.
- News release issuance Whether or not the AIC is activated, OEA reviews the news release with the Governor's office and obtains approval of the release from the Manager. OEA provides early notification to state agencies, issues the news release, and provides appropriate offsite notification.
- MBC activation After a further assessment of media response, OEA evaluates the need for a Media Briefing Center (MBC). If an MBC is to be established, OEA determines the MBC location and directs the necessary Contractor technical and administrative support. OEA identifies the technical interviews required.
- Closeout OEA continues to analyze the volume of inquiries, to direct media response, and to obtain incident status information. When the incident is concluded, OEA prepares and delivers a closeout statement.

The first step in implementation of an effective Emergency Planning and Response Program is the development of SRP site-specific emergency response plans in cooperation with affected state and county officials and agencies. DOE-SR has recently entered into agreements with lead agencies of South Carolina (DOE, 1983m) and Georgia (DOE, 1983n) to prepare such plans. The Department is providing staff assistance to develop these plans and will conduct exercises to assure that they provide appropriate responses. These agreements delineate the purpose, authorities, stipulations, responsibilities, and implementation procedures for developing the required plans.

For the Onsite Radiological Emergency Response Plan, SR402, Figure H-5 shows the lines of communication and coordination to be followed during a response. Figure H-6 shows the steps to be followed to make decisions and take actions related to reporting, activating the Emergency Operations Center, activating emergency management teams, making offsite modifications, and activating the Offsite Technical Coordination Center (OTCC). The plan includes sublogic networks for each activity step (circles), so directions and procedures at the most detailed level are available. The logic in Figure H-6 begins with the discovery of a radiological incident by a reporting source and includes the activities that follow:

- Incident Discovery Response. On discovery of an incident, the reporting source must determine if it is an emergency. If the incident is an emergency, the reporting source notifies the Emergency Operation Center (EOC) Patrol, which activates the EOC. If the reporting source does not classify the incident as an emergency, he or she notifies the EOC Patrol and the contractor management. Contractor management assesses the incident and either activates the EOC or notifies SR management to make that decision. In the latter case, SR management assesses the incident and



Source: DOE, 1983f

Figure H-5. Lines of communication and coordination for an onsite radiological emergency response.

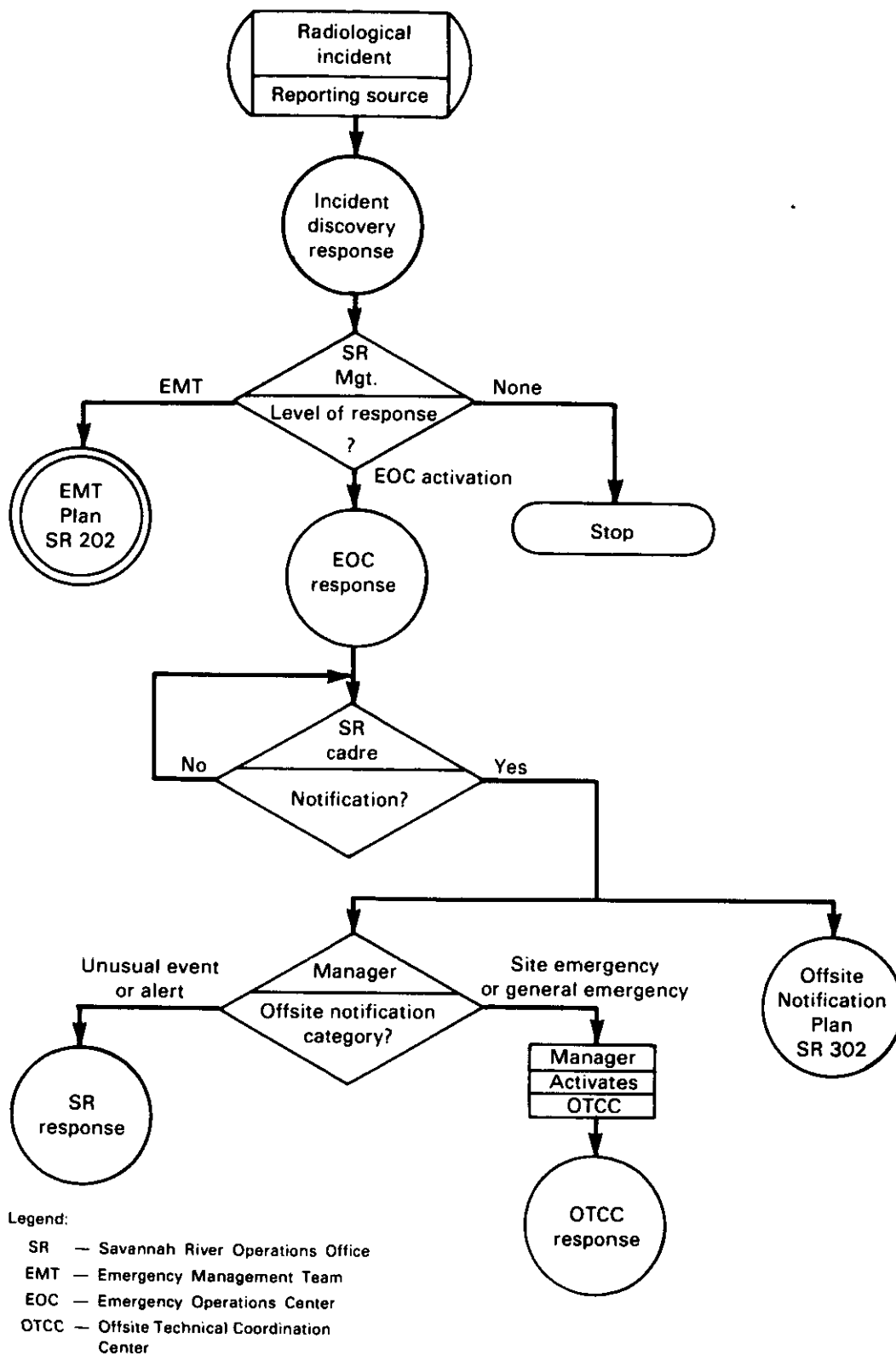


Figure H-6. Overview logic of the onsite radiological emergency response plan.

determines whether the incident requires EOC or Emergency Management Team (EMT) activation or no further action.

- EOC Response. After the decision has been made to activate the EOC, the EOC patrol notifies the EOC Cadre. The cadre reports to the EOC and obtains the emergency Incident Summary to identify characteristics that will enable it to make an assessment. EOC Cadre recommendations are forwarded to the Manager concerning incident mitigation procedures, SRP impacts, required logistical support, security requirements, worker and safety impacts, medical requirements, classification requirements, public impacts, and the need for media and other offsite notifications.
- SR Response. The Manager determines the SR response to offsite radiological incidents. He is assisted by senior SR management staff who are part of the EOC Cadre. SR maintains technical coordination with both the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Environmental Protection Division (GA EPD); controls access to the SRP plant site; maintains coordination with the Georgia Emergency Management Agency (GEMA) and the South Carolina Emergency Preparedness Division (SCEPD); and monitors control and mitigation actions.

The level of SR response is determined by the selection of an offsite notification category. If the incident is classified as an unusual event or alert, the EOC Cadre advises the states on offsite consequences and advises the Manager on whether to activate the OTCC.

If the EOC Cadre does not recommend activation of the OTCC, it maintains coordination and communication with state authorities until the incident is terminated. Periodically the cadre reevaluates the need to activate the OTCC.

In addition, the Manager directs the deployment of the offsite liaison and ensures that technical briefings are provided and response actions outside procedures are assessed. Offsite liaison is provided to state authorities (Georgia and South Carolina Forward Emergency Operating Center (FEOC)) and commercial operators (Barnwell and Vogtle). The offsite liaison advises these authorities on the status of the incident. The offsite liaison in turn advises the EOC Cadre of the response actions of the state and commercial authorities. Briefings provided by the offsite liaison, in addition to technical briefings, allow the EOC Cadre to brief the Headquarters EOC on the incident status; it does this periodically throughout the incident.

The EOC staff also assesses response actions outside of established procedures. Based on recommendations, the Manager decides to initiate response action outside of procedures.

- OTCC. After the decision has been made to activate the OTCC, the EOC Cadre determines its staffing requirements. The cadre notifies OTCC participants. The OTCC staff (onsite and offsite participants) has three primary functions: to coordinate radiological monitoring, to advise the EOC on the state assessment of offsite consequences, and to conduct periodic briefings on the onsite situation. When the OTCC staff

TC

has completed these activities and the incident has terminated, the OTCC is deactivated. The EOC Cadre then advises offsite authorities and DOE-HQ of the termination of the incident and the Manager submits a formal report to the Secretary.

H.2.2 Savannah River Plant site-specific contractor response plans

TC

DOE-SR's operating contractor for the Savannah River Plant is E. I. du Pont de Nemours and Company (Du Pont). Du Pont has been responsible for preparing all the onsite emergency response plans and for carrying out their responsibilities under these plans. All onsite plans developed by Du Pont are submitted to DOE-SR for approval before they are implemented. The Emergency and Disaster Plans for the Savannah River Plant (Du Pont, 1981) implement the onsite portions of the DOE-SR's Comprehensive Emergency Preparedness and Response Plan (DOE, 1983a). These two plans are the foundation of the DOE-SR Emergency Management Program. There are many subtier plans of both documents that implement the specific facility, process, or event aspects of the general plans. All necessary plans have been prepared and exercised in simulated operating conditions and/or utilized in actual emergency incidents. Table H-3 lists the key subtier plans. These plans will be integrated with state and local offsite plans, so the total response to SRP incidents will be coordinated adequately and appropriately. DOE-SR has entered into an MOU with The Dwight David Eisenhower Army Medical Center at Fort Gordon, Georgia, in which the parties have agreed to assist in SRP emergencies and accept radiation-exposed or contaminated emergency patients (DOE, 1982). See Appendix G for additional details of onsite planning.

H.2.3 South Carolina and Georgia state plans

As described in Section 1.0, general radiological emergency response plans exist for both states. Additionally, both states have site-specific radiological emergency response plans for nuclear power plant incidents which establish emergency organizations, and assign responsibilities and resources. These general plans with overall direction have been determined adequate by responsible state agencies and respective radiological response plans for nuclear power plant facilities have been approved by the Federal Emergency Management Administration (FEMA), the Nuclear Regulatory Commission (NRC), and other appropriate agencies. These plans provide an effective basis for the development of site specific response plans for the SRP.

H.2.4 County plans

South Carolina Counties of Aiken, Allendale, and Barnwell, and the Georgia County of Burke have existing emergency plans (e.g., ACCD, 1982; AEPA, 1982) in varying stages of formalization. These plans assign responsibilities for responding to general emergency situations. The general portions of the Aiken and Allendale County plans have been approved by the State. Aiken County has a full-time emergency preparedness director and Allendale County has a part-time emergency preparedness director. The general portion of the Barnwell County

Table H-3. Subtier Emergency Plans to Support "Emergency and Disaster Plans for Savannah River Plant" (Du Pont, 1981)

DPSOP Numbers ^a	Title
67	Emergency and Disaster Plans - Reactor Department
67-1	Fire Control Plan: 100 Areas
115-FH	200 Areas Emergency and Disaster Plans
115-2FH	Fire Protection Plan for 200 Areas
119	Emergency and Disaster Plans, 300/700 Area
119-1	Fire Control Plan, 300/700 Area
130-2	Separations Process, Building 221-F
135	400 Area Emergency and Disaster Plan
135-1	Fire Control Plan: 400 Area
147-3	HM ^b Process: 221-H Industrial Hazards
178	Fire Control Plan for SRP
179	Emergency and Disaster Plans for Health Physics Section
181	Emergency Actions: Medical Department and Security Division
307	Consolidated Communication Center Equipment
47	CMX-TNX ^c Emergency and Disaster Plans

^aDocument identification numbers

^bEnriched uranium process

^cExperimental and testing area

plan is complete and the county has a full-time emergency preparedness director. The general portion of the Burke County plan is not formalized but the county has a part-time emergency preparedness director. Richmond County is not included in the EPZ or the CPZ. However, because the county has a relatively large population, planning for notification and public education will be conducted. Specific plans for responses to SRP incidents are being developed with staff assistance from DOE-SR.

AY-8

H.3 OFFSITE PLANNING

Because portions of the EPZ and CPZ fall outside SRP boundaries, within state and county jurisdictions, a higher degree of planning has been considered by these governments. The specific nature of capabilities to meet these requirements has been determined in cooperation with responsible state and county agencies. General program requirements also include drills and exercises to evaluate plans and responses for incidents at the Savannah River Plant.

H.3.1 Department of Energy plans

AY-8,
EM-40

All DOE-SR Emergency Management Plans are complete. The Department of Energy has consulted with appropriate state and county officials and agencies and has provided staff assistance in the development of detailed offsite plans for the EPZ and CPZ to respond to incidents at the SRP. The site-specific aspects of these plans include actions to be taken by the Department of Energy and provide for coordination with state and county officials. Additionally, these plans provide information and guidance on responses to incidents at the Plant and the use of resources to disseminate and/or take action on the guidance. Formal agreements have been reached between the states and DOE-SR to conduct appropriate exercises to assure the necessary coordination, integration, and implementation (DOE, 1983m,n).

H.3.2 South Carolina and Georgia plans

TC

Site-specific SRP emergency response plans for South Carolina and Georgia provide prompt notification of SRP incidents to responsible officials in the EPZ and CPZ. The States' general radiological response plans are presently based on a full NRC-type Emergency Planning Zone response. Plans for the SRP EPZ address comparable considerations. These requirements include the following:

- Organization and Assignment of Responsibilities - to assure that emergency organizations are established and responsibilities assigned and included in written emergency plans.
- Emergency Response Support and Resources - to ensure that arrangements are made for requesting and effectively using outside assistance resources.
- Emergency Response Level Plans - to assure that a standard emergency response level plan is adopted and the associated response actions for each emergency response level are established.
- Notification Methods and Procedures - to assure that notification procedures and message content are developed and means of notification are established.
- Emergency Communications - to assure that provisions exist for prompt communications among principal response organizations, emergency response personnel, and appropriate Federal, State, and local officials.
- Public Education and Information - to ensure that public education is provided and that plans are in place for a coordinated media program.
- Emergency Facilities and Equipment - to ensure adequate facilities and equipment are provided and maintained to support emergency response.
- Accident Assessment - to ensure that adequate methods, systems, and equipment for assessing and monitoring actual or potential offsite consequences of a radiological emergency condition are in use.

- Protective Response - to assure guidelines are developed and are in place for protective actions for emergency workers and the general public.
- Radiological Exposure Control - to ensure guidelines and means for controlling radiological exposures are established for emergency workers.
- Medical and Health Support - to ensure that arrangements are made for medical services for contaminated injured individuals.
- Recovery and Re-entry Planning and Post Accident Operations - to assure general plans for recovery and re-entry are developed.
- Exercises - to ensure that DOE, state and local organizations conduct periodic exercises to develop and maintain key skills.
- Radiological Emergency Response Training - to ensure that training programs are provided for management officials, specialized emergency duty personnel, and all other personnel having emergency responsibilities.
- Memoranda of Understanding and Letters of Agreement - to ensure that appropriate instruments of agreement/understanding have been entered into with onsite and offsite support organizations.

To ensure the adequacy of plans, the Department of Energy will conduct an annual exercise and provide the opportunity for state and county government participation. The basic responsibility of state and county government emergency preparedness organizations is to provide appropriate capabilities for responding to potential emergencies that may occur in their jurisdiction.

Plans for the CPZ will focus more on:

- Incident notification
- Emergency public information and education
- DOE/state communication and coordination
- State/county communication and coordination.

State emergency response plans for SRP were completed in March 1984.

AY-8,
EM-40

H.3.3 County plans

County emergency response plans for the SRP supplement the general county emergency plans and provide for the implementation of appropriate actions related to an SRP incident. Site-specific plans identify the organizations, responsibilities, resources, and coordination to be undertaken by the county in such cases. Interfaces with the Savannah River Plant and with state emergency preparedness organizations have been established. Areas considered during this planning include notification, communication and coordination, public information, public warning, law enforcement, and protective response (sheltering, evacuation, or other protective action), depending on whether portions of the county are in the EPZ, the CPZ, or both.

County Emergency Response Plans include site-specific radiological plans relating to incidents at the Savannah River Plant and follow a standardized format approved by the states that support the state plans on a site-specific basis.

No requirement exists for public warning outside the Emergency Planning Zone. However, specific plans for public notification within the CPZ and general plans for notification in outlying areas have been implemented at an appropriate level, having been determined through the ongoing planning process between DOE and officials of state and county governments.

H.4 SUMMARY

The Department of Energy has emergency plans to respond to onsite incidents at the SRP. The South Carolina Operational Radiological Emergency Response Plan is completed; it includes a site-specific Radiological Emergency Response Plan for the Savannah River Plant. The State of Georgia Radiological Emergency Plan also includes a site-specific Radiological Emergency Response Plan for the SRP. County plans are complete for the site-specific radiological plans for the EPZ or CPZ.

Department of Energy personnel, working with state and county emergency preparedness officials, have identified the organizations, responsibilities, coordinations, and resource aspects of participating agencies. State and county jurisdictions/issues were resolved before the completion of state plans. County plans support the state plans on a site-specific basis. All plans were completed by March 31, 1984.

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APPENDIX I

FLOODPLAINS/WETLANDS ASSESSMENT*

Executive Orders 11988 (Floodplains Management) and 11990 (Protection of Wetlands) and U.S. Department of Energy (DOE) regulation "Compliance with Floodplain/Wetlands Environmental Review Requirements (10 CFR 1022)" specify the requirements for a floodplain/wetlands assessment.

DOE issued a floodplain/wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A floodplain/wetlands determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The updated and/or modified floodplain/wetlands determination will follow the completion of this EIS.

This appendix describes the effects on floodplains and wetlands that would result from the direct discharge of L-Reactor cooling water to Steel Creek, or from the implementation of alternative cooling systems, as discussed in Section 4.4.2. Some estimates of wetlands losses have been revised since the DEIS due to the availability of new data. These alternatives include the following:

Once-through alternatives

- Direct discharge to Steel Creek (reference case)
- Spray canal
- Small lakes
- Small lakes with spray cooling (1-2 sets)
- 500-acre lake
- 500-acre lake with spray cooling (1-2 sets)
- 1000-acre lake
- Diversions to Pen Branch

Mechanical-draft cooling tower alternatives

- Once-through with discharge to Steel Creek
- Once-through - canal to swamp
- Once-through - spray canal and canal to swamp
- Once-through - canal to swamp; pipe to river
- Total recirculation - blowdown to Steel Creek
- Total recirculation - blowdown treatment
- Partial recirculation - with discharge to Steel Creek
- Partial recirculation - with refrigeration

Other recirculation alternatives

- Recirculation through creation of L-Pond
- Recirculation through creation of Kal Pond
- Recirculation through creation of High-Level Pond
- Recirculation through Par Pond

*Vertical change bars have not been used in this appendix because of the extensive revisions that have been made.

Other alternatives

- Thermal cogeneration
- Low-head hydropower
- Modified reactor operation
- Fisheries management programs
- Protect similar wetlands

I.1 WETLANDS

I.1.1 Direct discharge to Steel Creek (reference case)

Direct discharge would release about 11 cubic meters of thermal effluent per second from L-Reactor directly to Steel Creek, as was done during the pre-1968 operation of L-Reactor. Modeling of L-Reactor liquid discharges indicates that the thermal effluent will be discharged to Steel Creek at a maximum temperature of 73°C. Cooling will occur as the effluent flows to the Savannah River. The thermal effluent will enter the swamp at temperatures between 41°C (spring) and 46°C (summer). When L-Reactor is operating, the segment of Steel Creek above the swamp will be subjected to temperatures 19° to 38°C above ambient in summer, spring, and winter.

The species found in Steel Creek today are typical of those in similar non-thermal streams at the Savannah River Plant. The presence of stoneflies, mayflies, caddisflies, and dragonflies indicates that Steel Creek is recovering from prior cooling-water discharge impacts. Collections of species of crustaceans (crayfish) have been similar in both Steel Creek and the nonthermal Upper Three Runs Creek. About 50 species of fish have been collected from 1981 to 1983 from Steel Creek (Smith, Sharitz, and Gladden, 1981, 1982, 1983). The present diversity of organisms in Steel Creek indicates that post-thermal recovery of the macroinvertebrate communities has progressed during the past 15 years.

L-Reactor discharge is expected to have effects similar to those that occurred during previous operations; this is described in Section 4.1. Flooding and siltation associated with the thermal discharge are expected to adversely affect aquatic habitat in the Steel Creek floodplain and delta area. An estimated 730 to 1000 acres of wetlands will receive adverse impacts from the direct discharge of thermal effluent to Steel Creek. These wetlands, which have become established during the past 15 years through the process of natural succession, are structurally different from the closed canopy of mature cypress and tupelo gum that existed before the SRP began operation. These wetlands include approximately 420 to 580 acres of the Steel Creek corridor and between 310 to 420 acres of swamp (approximately 250 acres of swamp are expected to receive adverse impacts almost immediately; the remainder would be affected at a rate of about 7 to 10 acres per year). The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981). The delta is expected to expand into the swamp at a rate of about 3 acres per

year. Aquatic macrophytes and woody plants will be eliminated in the Steel Creek corridor. Species that inhabit cooler backwater pools or other suitable substrates might experience a reduction in productivity.

After the resumption of operations, emergent wetland flora and submergent hydrophytes will be eliminated and their substrates will revert to mudflats. Some herbaceous flora will become established on exposed floodplain sediments and elevated stumps, and logs of fallen trees. Most shrubland communities also will probably be eliminated. Riverine vegetation in the vicinity of the mouth of Steel Creek consists primarily of bottomland hardwood forests; emergent and submergent macrophytes are sparse or absent. It is improbable that the thermal effluent would impact these riverine flora.

During thermal discharge, Steel Creek above the delta will be inhabitable for most aquatic life. In addition, the water temperature of Steel Creek might isolate the floodplain swamp from river fish. Most, if not all, spawning activity will probably be eliminated. The most common fish remaining in the Steel Creek area probably will be the mosquitofish, although a few centrarchids might occur in backwater areas and tributary streams such as Meyers Branch (Cherry et al., 1976; Falke and Smith, 1974; Ferens and Murphy, 1974; McFarlane, 1976; McFarlane et al., 1978).

Although 2280 acres of the wetlands along Steel Creek above L-Area and along Meyers Branch above its confluence with Steel Creek will not receive direct thermal discharges, access to these areas by fish from the Savannah River will be restricted. The entrance to Boggy Gut Creek, an offsite tributary immediately downriver of Steel Creek, could be blocked at times by the thermal plume; fish access would be limited. Wetland areas of Boggy Gut Creek total about 230 acres.

Except for backwater pools or other cool-water refuges, the high water temperatures from the outfall to the delta will make this section of Steel Creek uninhabitable for amphibian eggs and larvae. Adult life forms might survive along the stream margins or relocate to adjacent habitats.

Reptiles depend more on aquatic habitat for food (i.e., insects, fish, amphibians) and shelter than for reproduction. The elevated water temperature and the elimination of prey organisms will eliminate the habitats of semiaquatic snakes and turtles upstream from the delta, and will cause a marked decrease in species richness. Portions of the delta might provide marginal habitat for water snakes and turtles following L-Reactor restart.

The endangered American alligator inhabits all parts of Steel Creek from the L-Reactor outfall to the cypress-tupelo forest adjacent to the Steel Creek delta; it also uses areas lateral to Steel Creek, including Carolina bays, backwater lagoons, and beaver ponds. The number of alligators inhabiting the Steel Creek area has ranged from 23 to 35 individuals. Telemetry studies showed that adult males had larger home ranges than juveniles and females. Males sometimes moved from the delta into the Savannah River swamp (Smith, Sharitz, and Gladden, 1982).

Direct discharge will eliminate alligator habitat in Steel Creek from the reactor outfall to the Savannah River, except for backwater pools or other cool-water refuges, by increasing the water temperature above limits that are

physiologically tolerable, eliminating its principal food sources, and possibly inundating its nests and shallow-water wintering habitats (Smith, Sharitz, and Gladden, 1981, 1982). Adult alligators can avoid thermal waters and migrate considerable distances overland. Overwintering alligators could be killed by thermal effluent if they were in a torpid condition. Juveniles could also avoid thermal effluents, but smaller alligators might experience difficulty in migrating to suitable habitats and could be more subject to predation. Nesting sites and eggs could be inundated and destroyed. Red sore, a bacterium-caused disease that affects fish and reptiles, could become more prevalent with thermal loading and could affect the American alligator. Conditions conducive to the reproduction of this bacterium, however, are very specific (i.e., water temperature, pH, etc.), and are associated more with lentic (nonflowing) ecosystems such as Par Pond. This bacterium currently appears isolated in Par Pond, and its presence has not been confirmed in SRP stream ecosystems.

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). A Biological Opinion was received from the FWS in which FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially impacted by L-Reactor restart. Protection of these lagoons has been completed. DOE has reinitiated consultations with FWS (Sires, 1983).

The Savannah River swamp and Steel Creek delta provide an important regional sanctuary and refuge for waterfowl. More than 400 wood ducks and nearly 1200 mallards have been observed roosting and feeding in the Steel Creek delta. Seven other species of waterfowl also use this area. These habitats will be eliminated by direct discharge.

The Steel Creek delta also provides important foraging habitat for the wood stork, a large wading bird that is listed as an endangered species (USDOI, 1984). A total of 478 observations of foraging wood storks was made in the Savannah River swamp in 1983, of which 102 were in the Steel Creek delta. Thermal discharge will eliminate these feeding habitats. DOE has initiated a consultation process with the U.S. Fish and Wildlife Service on the wood stork.

Semiaquatic mammals that will be affected by the thermal effluent include the beaver, river otter, mink, and muskrat. Except for the muskrat, these species are common throughout the Savannah River Plant. Adults should not experience mortality due to increased flow and temperature.

I.1.2 Once-through alternatives

I.1.2.1 Once-through spray canal system

This alternative would provide a spray canal to reduce L-Reactor effluent temperatures before the effluent is discharged to Steel Creek. During the summer, effluent entering this spray canal at a rate of about 11 cubic meters per second would be cooled by about 5°C and discharged to Steel Creek at about 73°C. Based on thermal modeling, extreme summer effluent temperatures at Road A and Steel Creek delta would be 53°C and 45°C, respectively. These temperatures

are slightly cooler than those of the direct-discharge effluent at the same locations. Given this slight reduction in effluent temperature and identical flow rates, the impact of a spray canal on wetlands would not differ significantly from that of direct discharge. Delta growth would be about 3 acres per year, and as many as 785 to 1005 acres of wetlands would be impacted. Additionally, approximately 110 acres, half of which are wetlands, would have to be cleared in the vicinity of the spray system in order to enhance cooling performance. If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be essentially the same. Any mitigative effects resulting from the small lakes alternative would not begin until the end of the 18- to 24-month construction period. Furthermore, this system offers no mitigation to the habitat of the endangered American alligator, the endangered wood stork, migratory waterfowl, or other aquatic species.

Wetland impacts expected from implementation of the spray canal system would not differ appreciably if this system was implemented either before or after L-Reactor restart (a maximum of 1060 acres compared to 1005 acres).

I.1.2.2 Small lakes on Steel Creek

A series of rubble dams on Steel Creek could provide several small lakes with a combined area of about 120 acres. The thermal effluent discharged through these lakes at 11 cubic meters per second and under maximum summer conditions would be cooled to about 45°C on discharge from the last lake and 40°C where Steel Creek enters the swamp. This cooling system would provide limited use of Steel Creek below Road A by some thermally tolerant aquatic organisms. However, this system would not maintain alligator habitat below Road A, because of the general loss of prey organisms. Although this alternative provides some mitigation below Road A, thermal impacts will occur. Delta growth would be about 2 acres per year, and as many as 1000 acres of wetlands would be adversely affected by flooding, siltation, and thermal impacts. Flooding, controlled by the reactor operation schedule, would be intermittent and would cause fluctuating water levels. The cooler temperatures near the delta would result in a decreased rate of vegetative mortality. However, flooding, siltation, and fluctuating water levels, when coupled with the thermal effects, would have adverse impacts on wetlands that are classified as Resource Category 2 by the U.S. Fish and Wildlife Service (USDOI, 1981). This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value." In addition, about 2500 acres of wetlands could be physically isolated by the dams and thermal temperatures.

I.1.2.3 Small lakes with spray cooling (1-2 sets)

The combination of small rubble dams to create approximately 120 acres of shallow lakes combined with a spray cooling system (1-2 sets) would mitigate some of the environmental effects of a direct discharge system. The gravity spray canal system would be installed to obtain about 5°C cooling before the

water enters the first lake. The small dams would create pools that would slow the movement of the water and enhance cooling. Maximum exit temperatures in the summer would be 44°C with one spray system or 39°C with two spray systems. In the swamp the effluent would be cooled to 34°C and 37°C, respectively.

The use of small lakes without sprays would impact between 420 and 580 acres of wetlands in the Steel Creek corridor and between 310 and 420 acres of wetlands in the delta and swamp. The use of sprays (1 or 2 sets) would impact an additional 55 acres of wetlands in the vicinity of the spray canal. However, the cooling achieved by sprays would reduce the impacts to the delta and swamp to between 215 and 335 acres of wetlands. Thus, the total wetlands impacted by small lakes without sprays would range between 730 and 1000 acres. Small lakes with sprays (1 or 2 sets) would impact between 690 and 970 acres of wetlands. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce its becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOT, 1981).

Erosion and transport of sediment will increase because the flow rate will be about 11 cubic meters per second. A delta growth rate of about 2 acres per year is anticipated. In addition to sedimentation and erosion from flow, some sedimentation will be associated with construction of the embankment; however, it will be covered by an erosion/sedimentation plan. Spoil removed from the embankment site will contain small amounts of radioactivity. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

If the small lakes alternative (1-2 sets) is implemented before direct discharge occurs, the environmental effects would be as described above. If it is implemented after direct discharge starts, the environmental effects would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from small lakes with sprays (1-2 sets) would not begin until the end of the 18- to 24-month construction period.

I.1.2.4 500-acre lake

The impacts on wetlands from a 500-acre lake on Steel Creek would generally be similar to those for the spray canal and small lakes systems. Although lower maximum summer effluent temperatures are projected at Road A (37°C) and the delta (36°C), the high rate of flow and fluctuating water levels would adversely affect the wetland vegetation. Macrophytes would be uprooted by strong currents, and woody flora would be eliminated due to prolonged inundation. Reproduction of wetlands vegetation in most areas would be uncommon because of the flooding and fluctuating water levels associated with reactor operation. Roosting and feeding habitat for waterfowl will be lost. In addition, the

fluctuating water levels are expected to discourage spawning and inhibit the successful reproduction of fish. Even with lower effluent water temperatures below Road A, vegetation will be lost in the Steel Creek corridor and on the delta. Habitat quality for the American alligator will be reduced in Steel Creek below Road A because of the loss of prey organisms.

Delta growth is projected to be 2 acres per year. Between 650 and 930 acres of wetlands would be impacted by this action. This includes between 435 and 595 acres in the Steel Creek corridor and between 215 and 335 acres in the delta and swamp. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981). Approximately 2280 acres of riparian wetlands associated with Meyers Branch and the upper headwaters of Steel Creek could be isolated. As many as 360 acres of upland vegetation would be inundated by the impoundment. The principal difference between this option and direct discharge or spray canal options is not the magnitude, but the rate and location of impacts. Cooler temperatures in peripheral areas of the delta should enable limited vegetative establishment. Flooding, siltation, and fluctuating water levels, when coupled with thermal effects, would halt the vegetative succession that has been progressing in the swamp since 1968.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts to wetlands would be as described above. If it is implemented after direct discharge occurs, there would be some limited mitigation, but this would not begin until the end of the 18- to 31-month construction period. The construction of this alternative could be expedited to about 6 months.

I.1.2.5 500-acre lake with spray cooling (1-2 sets)

Combinations of several once-through cooling-water systems could have fewer thermal effects than a single system. The combined system discussed in Section 4.4.2 consists of a 500-acre lake with a spray cooling system (1-2 sets). The gravity spray canal system would obtain about 5°C cooling before the water enters the lake. This water (at 73°C) would be cooled to about 38°C during its travel through the lake (under extreme meteorological conditions). A system with two sprays would cool the water to less than 32°C before discharging it to Steel Creek. With a single spray system located above the 500-acre lake, the maximum summer discharge temperature from the lake would be 37°C.

Approximately 705 to 985 acres of wetlands habitat would be lost with one or two sets of sprays. This would consist of 490 to 650 acres in Steel Creek corridor and 215 to 335 acres in the delta and swamp. This system would not mitigate flooding and fluctuating water levels in the Steel Creek system. Therefore, the principal differences between the combined system and other once-through systems would be a decreased rate of vegetative mortality in the Steel Creek corridor and delta below the final spray lake; it is possible that fish and other organisms would be able to use the creek below the dam.

If the 500-acre lake with spray cooling system (1-2 sets) is implemented before direct discharge occurs, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.2.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). The mitigative effects resulting from this alternative would not begin until the end of the 31- to 36-month construction period.

I.1.2.6 1000-acre lake

This alternative consists of the construction of a 1000-acre once-through cooling lake on Steel Creek. The normal water surface elevation would be 61 meters above mean sea level. The embankment for this cooling lake would be at the same location as the embankment for the 500-acre lake described in Section 4.4.2. The impacts from the 1000-acre lake were bracketed by those from the 500-acre lake and the 1300-acre lake described in the Draft EIS.

Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 1°C of ambient. In the spring, water temperatures at the delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions do not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7°C to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in a gradual heat loss in this area, which would minimize any cold shock effects. This alternative would not adversely affect access to, and the spawning of riverine and anadromous fishes in, the Savannah River swamp below the Steel Creek delta.

The habitat impacted by the 1000-acre lake would include between 520 and 680 acres of wetlands in the Steel Creek corridor. The flow of discharge water would have adverse impacts on between 215 and 335 acres of wetlands in the Steel Creek delta and swamp. This area, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetlands, provides foraging habitat for the endangered wood stork and American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. A delta growth rate of about 1 to 2 acres per year is anticipated. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of in-kind habitat value" (USDOI, 1981).

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above. If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from the 1000-acre lake alternative would not begin until the end of the 35-month construction period. Construction of this alternative could be expedited to about 6 months.

I.1.2.7 Once-through cooling by diversions to Pen Branch

This alternative includes two options: (1) a diversion to Pen Branch by penstock and canal, and (2) a diversion to Pen Branch by lake and canal.

The lower segment of Pen Branch presently receives thermal effluent from K-Reactor. Depending on the diversion option, approximately 2 to 5 kilometers of Pen Branch above Indian Grave Branch that have never received thermal discharge would receive heated effluent from L-Reactor. Flows in this reach would be about 10 times the natural rate at the point of L-Reactor discharge, resulting in appreciable stream erosion. Portions of Pen Branch are expected to be severely eroded by the downcutting, widening, and straightening of its channel. A mixture of sand and mud would be deposited in its delta region, resulting in the growth of the delta by 18 acres or more per year during the first 7 to 10 years of combined K- and L-Area discharges to Pen Branch and eventually modifying the heat dissipation characteristics of the swamp. Below the confluence of Pen Branch and Indian Grave Branch, the combined K- and L-Reactor discharges would double the flow of Pen Branch. The effluent temperature is estimated to be 58°C when it enters the swamp. Approximately 1280 acres of wetlands are expected to be adversely impacted: this would consist of (1) a small portion of Steel Creek (60 acres), (2) a previously unimpacted part of Pen Branch (50 acres), (3) the Pen Branch delta (210 acres), and (4) 960 acres of the Savannah River floodplain. No mitigation of swamp habitat for the endangered American alligator or wood stork would be achieved by this alternative.

The diversion of L-Reactor cooling water by a penstock canal to Pen Branch would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of wetlands in Steel Creek, delta, and Savannah River floodplain would receive no impact. However, about 1220 acres of previously undisturbed wetlands in the Pen Branch (55 acres), its delta (210), and the Savannah River swamp (960 acres) would be affected by the diversion. Implementation after restart would impact between 730 and 1000 acres of wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the diversion, the wetlands in the Steel Creek and portions of the Savannah River swamp system could reinitiate a successional recovery.

The implementation of the lake-diversion system before or after L-Reactor restart would be similar to that for the penstock canal diversion except for (1) the 60-acre lake caused by damming Steel Creek and (2) the smaller reach of Pen Branch that has not previously received thermal discharges.

I.1.3 Mechanical-draft cooling towers

Mechanical-draft cooling towers added to the L-Reactor site could utilize three principal modes of operation: (1) once-through with direct discharge to Steel Creek, the swamp via a canal, or the Savannah River via a canal and pipeline, (2) total recirculation via the 186-Basin, or (3) partial recirculation with and without refrigeration. A summary of the impacts to floodplains and wetlands from the various alternative cooling systems is given below.

I.1.3.1 Cooling towers with once-through and direct discharge

I.1.3.1.1 Once-through and direct discharge to Steel Creek

This alternative would discharge cooling effluent into Steel Creek at a somewhat lower rate of flow (10.2 cubic meters per second) due to evaporation losses. The temperature of the effluent would be lowered by the towers, and would vary according to the approach to the design wet bulb temperature (i.e., 2.8° or 5.6°C). Temperature of Steel Creek in summer and spring would be at or near ambient above Steel Creek delta (2.8°C approach); in winter temperatures would be 7°C above ambient at the delta. The 5.6°C approach could have adverse effects on Steel Creek because the discharge temperatures would be about 31°C during a 5-day period that is expected to occur once about every 5 years. Otherwise the 5.6°C approach tower will meet the 32°C water-quality standard about 99 percent of the time.

The towers would substantially mitigate the effects associated with direct discharge temperatures; the environmental impacts of this alternative would be less than those for direct discharge; they are summarized as follows:

- High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have markedly elevated temperatures, high flow rate would impact between 70-80 percent of the delta and swamp area predicted for direct discharge. Thus, between 215 and 335 acres of delta or swamp wetlands would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. This would include foraging habitat of the endangered wood stork and the endangered American alligator.
- The spring temperatures should not affect approximately 2500 acres of wetlands and aquatic habitat for spawning riverine and anadromous fishes and other semiaquatic biota because spring temperatures in the swamp and delta would be within 4°C of ambient.
- No impacts to substrate, water quality, or water levels due to dredging and filling.

If this alternative is implemented before restart occurs, environmental impacts would be as described above (i.e., loss of about 635 to 915 acres of wetland due to high flow). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.2 Once-through - canal to swamp

This alternative would directly discharge cooling-water effluent into a canal at a rate of 10.2 cubic meters per second. This canal would bypass the Steel Creek corridor and discharge through a diffuser in the vicinity of Steel Creek delta.

This alternative (all approaches) would avoid Steel Creek down to the swamp, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via the canal near Steel Creek and enter the swamp through a diffuser at temperatures between 23°C and 28°C during the spring, which would allow riverine and anadromous fish and other biota to have access to the swamp during the spawning season. Temperatures at the delta during the summer would be 28°C and 31°C for the 2.8°C and 5.6°C approaches, respectively. However, the impacts on the swamp from the 10.2-cubic-meter-per-second flow would be almost the same as those described for direct discharge.

The canal would be routed adjacent to Steel Creek above the floodplain and extend for approximately 10.4 kilometers before discharging at the delta. The canal would impact about 120 acres of upland pine forest and open fields, and require the disposal of approximately 850,000 cubic meters of spoil.

This alternative cooling system would have no impact on endangered and threatened species that inhabit Steel Creek above its delta because the creek corridor would not receive thermal effluent. The discharge of 10.2 cubic meters per second through a diffuser located at the Steel Creek delta might channelize portions of the existing wetlands. Between 215 and 335 acres of wetlands in the delta and swamp would be impacted. However, the discharge temperatures (28°C and 34°C for 2.8°C and 5.6°C approaches in summer, respectively) would not adversely impact the American alligator. The greatest potential impact would result from elevated water levels, which could eliminate foraging habitat for the endangered wood stork. The shortnose sturgeon would be unaffected by this alternative.

Dredge material from the canal and the area in the swamp around the diffuser would be monitored and handled to meet applicable regulatory requirements. Thus, no significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or Savannah River due to dredge and fill activities.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetland in Steel Creek corridor and losses of 215-335 acres in the swamp). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.3 Once-through - spray canal and canal to swamp

This alternative would discharge cooling-water effluent into the swamp via a canal at a somewhat lower rate of flow (10.2 cubic meters per second) than direct discharge due to evaporation losses. The temperature of the effluent under this alternative would be identical in summer and spring to that of the alternative described in Section 4.4.2.3.1.2, minus the spray system. It would be lower in winter due to cooling by the spray system.

This alternative would include complete avoidance of Steel Creek down to the swamp, allowing approximately 420 to 580 acres of wetland to continue successional recovery in the Steel Creek corridor, including habitat for the endangered American alligator. The effluent would reach the swamp via a canal near Steel Creek and enter the swamp through a diffuser at temperatures between 28°C and 30°C (essentially 2°C below summer ambient temperatures; 2.8°C approach). This would allow access in the spring to the entire swamp and Steel Creek by spawning riverine and anadromous fish and other aquatic biota. However, the impacts on the swamp from the 10.2-cubic-meter-per-second flow would be the same or slightly less than those described for direct discharge.

Except for water temperatures slightly cooler (2°C) than ambient in the swamp and mouth of Steel Creek (with a 2.8°C approach tower), the environmental impacts of this alternative would be the same as those for cooling towers having once-through discharge via a canal to the swamp. These impacts are summarized as follows:

- No impact to the Steel Creek corridor, but increased flow rate would eliminate 215 and 335 acres of wetlands in the swamp.
- Approximately 120 acres of upland pine forest and open fields would be disturbed for construction of the canal; 850,000 cubic meters of spoil would have to be removed and stored or utilized. About 30 acres of upland pine forest would be removed for the construction of the towers. In order to achieve optimal cooling performance with one set of sprays, vegetation within 300 meters of the sprays must be cleared to enhance evaporative rates. This would eliminate approximately 55 acres of wetlands and 55 acres of upland habitat.
- No impact to the American alligator and shortnose sturgeon; foraging habitat of the endangered wood stork would be adversely impacted due to increased water levels.
- Modification of the bottom contour of the swamp in the vicinity of the diffuser.
- No impact to water quality or increased suspended particulates and turbidity would result from the dredging of the canal. Short-term impacts might be associated with the installation of the diffuser.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (successional recovery of 420 to 580 acres of wetlands in Steel Creek and loss of about 215 to 335 acres in the swamp due to high flow rate). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.3.1.2 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.1.4 Once-through - canal to swamp - pipe to river

This alternative would completely avoid Steel Creek and the swamp, allowing approximately 730 to 1000 acres of wetland to continue to undergo successional recovery and fish would have full access to Steel Creek and Swamp. However, access of fish to Boggy Gut Branch would be limited, especially during the spring and summer.

The diffuser would be constructed to mix the effluent rapidly with the river. Based on seasonal outfall temperatures, a zone of passage would be maintained to allow movement of anadromous fish past SRP; the mouth of Steel Creek would not be blocked by temperatures high enough to exclude riverine and anadromous fish from entering and spawning in the Steel Creek swamp system (for both 5.6°C and 8.2°C approach temperatures). Discharge temperatures might attract some fish species into the thermal plume during the winter; however, insignificant impacts are expected on riverine species due to overwintering stress.

The greatest impact to wetlands from this alternative would result from the construction of the pipeline. This raised structure would extend from a point near the Steel Creek delta to the Savannah River, a distance of 2500 meters. Pipeline construction could have adverse impacts on the Savannah River swamp because of: (1) piles driven into the substrate to support the pipeline, (2) the use of heavy equipment affecting wetlands through the compaction of substrate, and (3) increased erosion and sedimentation due to disturbances of the substrate.

The pipeline would be constructed above the high-flood mark (about 7 to 9 meters), so it could not act as a dam and impede water flow during flooding.

Proper buffers would be installed during construction to prevent movement of suspended particulates, which might cause turbidity impacts. Discharge water quality would be the same as that described for direct discharge. No significant changes in water quality, suspended particulates, or turbidity are expected to occur in the swamp or the Savannah River.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.2 Cooling towers - recirculation

I.1.3.2.1 Total recirculation - blowdown to Steel Creek

The 2.8°C and 5.6°C approaches recirculation alternatives would greatly reduce temperatures discharging to Steel Creek, and would result in a minimal impacts to the biota of the creek, its delta, the floodplain, and the Savannah River in comparison to the effects caused by direct discharge (see Section

I.1.3.1.1). The 2.8°C approach tower would continually meet the 32°C thermal standard except during extreme summer meteorological conditions; during these conditions it would exceed the limit by less than 1°C. The 8.3°C approach tower would not meet the 32°C thermal standard from late spring to early fall. All three approaches have low discharge rates (about 0.6 cubic meters per second), thus, impacts due to flow would be minimum.

The blowdown-to-Steel Creek ion-concentration ratio is expected to be about 3. Thus, the chemical constituents in the creek water near the L-Reactor outfall would be about 1.7 times their normal concentration without the blowdown. At Road A, the increases in concentration would be only about 1.4 times normal. The blowdown is not expected to have an appreciable impact on the water quality of Steel Creek, the swamp, or the Savannah River.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetland). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.2.2 Total recirculation - blowdown treatment

This cooling-system alternative (2.8°C approach) would discharge 0.6 cubic meter per second of blowdown effluent at essentially the same temperatures in summer and spring as those achieved by cooling towers having total recirculation. However, in winter and at other times as required, the blowdown would be treated to reduce its temperature and to assure compliance with the 2.8°C delta-T thermal standard. In summer and spring, near ambient temperatures would be achieved from the outfall to the Savannah River. Near-ambient winter temperatures would be reached along the creek, delta, swamp, and at the mouth of Steel Creek.

This alternative would have essentially the same environmental impacts as those resulting from the implementation of cooling towers having total recirculation (2.8°C approach) without blowdown cooling; these impacts are summarized as follows:

- Construction of the towers would affect approximately 30 acres of upland pine forest. There would be no impact to wetlands or the biota that inhabit the Steel Creek ecosystem and swamp.
- There would be no impact to endangered and threatened species, nor would any critical habitat, as designated by the U.S. Fish and Wildlife Service, be affected.
- Because of low discharge rate little or no change in present erosion or sedimentation patterns is expected. There would be no impacts to aquatic substrate or water quality from dredging and filling activities, because they are not required.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (successional recovery of about 730 to 1000 acres of wetlands). If it is implemented after direct discharge occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.3 Cooling towers - partial recirculation

Cooling towers (2.8°C or 8.3°C approach temperature) that only recirculate a portion of the cooling water could be added to the L-Reactor site. From April through October the towers would cool water on a once-through basis and discharge all the effluent directly to Steel Creek. Based on equilibrium temperature calculations for these months, the discharge to Steel Creek under normal weather conditions would continuously meet the 32°C/+2.8°C temperature standard if a 2.8°C approach cooling tower is used. Equilibrium temperature calculations indicate that, from November through March, a portion of the cooling water must be recirculated to the 186-Basin, the remainder of the water discharged to the creek at 10.9 cubic meters per second would be obtained by blending ambient river water with cooling-tower blowdown.

I.1.3.3.1 Partial recirculation - discharge to Steel Creek

Except for the mitigating effects associated with lower discharge temperatures (maximum summer discharge temperatures of 27°C to 28°C, depending on approach), the environmental impacts caused by this alternative (2.8 and 8.3°C approach) would be similar to those for direct discharge; they are summarized as follows:

- High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent will not have markedly elevated temperatures, high flow rate would impact between 70 to 80 percent of the delta and swamp area predicted for direct discharge. Thus between 215 and 335 acres would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOL, 1981).
- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.
- No impacts to substrate, water quality, or water levels due to dredging or filling.

- Increased sedimentation and erosion due to effluent discharge; delta growth is anticipated to be 3 surface acres per year.

If this alternative is implemented before the restart of L-Reactor, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after direct discharge occurs, environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.3.3.2 Partial recirculation - with refrigeration

This alternative is the same as the partial recirculation case described above except that a refrigeration unit would be used primarily at night during the winter, to meet state thermal discharge standards. The refrigeration system would operate about 2 to 5 hours per night from January through March. During those hours, about 1 cubic meter per second would be diverted through the refrigeration unit to give a maximum mixed Steel Creek temperature difference of about 2.8°C. The maximum summer discharge temperatures to Steel Creek would not exceed 30°C for either approach.

High flow rate would eliminate between 420 and 580 acres of wetlands within the Steel Creek corridor. Because the effluent would not have markedly elevated temperatures, high flow rate would impact between 70 to 80 percent of that predicted for direct discharge. Thus between 215 and 335 acres would be eliminated (or a total of 635 to 915 acres) due to high flow rate from this alternative cooling system. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

- Foraging sites for the endangered wood stork would be eliminated due to increased water levels.
- No impacts to substrate, water quality, or water levels due to dredging or filling.
- Increased sedimentation and erosion due to effluent discharge; delta growth is anticipated to be 3 surface acres per year.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above (i.e., loss of 635 to 915 acres of wetlands). If it is implemented after restart occurs, the environmental impacts would be the same as those described in Section 4.4.2.2.1 (i.e., loss of 730 to 1000 acres of wetlands, etc.). Any mitigative effects resulting from this alternative would not begin until the end of the 27-month construction period.

I.1.4 Recirculation alternatives

I.1.4.1 Recirculation through creation of L-Pond

Under this alternative, a recirculating lake would be constructed in the Steel Creek floodplain below L-Reactor; this lake would inundate approximately 1300 acres of floodplains, bottomland hardwood forest, and stands of upland pine. Under extreme meteorological conditions, discharges from this lake are expected to be about 33°C in the summer; the average discharge temperature would be about 31°C. Near ambient temperatures would be reached in Steel Creek near the delta. L-Pond would support minimal aquatic life because of a continually high water temperature. Isolated cool-water refuges might be utilized minimally by aquatic (fish) and semiaquatic biota (herpetofauna, wading birds, beaver). Approximately 7.6 kilometers of Steel Creek would be eliminated, including existing habitats of the American alligator. Approximately 240 acres of wetlands would be adversely impacted by the impoundment. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

The creation of L-Pond before restart occurs would eliminate thermal discharges to Steel Creek. Approximately 605 to 875 acres of wetlands in Steel Creek below the embankment, Steel Creek delta, and Savannah River floodplain would not be impacted and would remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor. However, about 240 acres of wetlands would be inundated.

Implementation after restart occurs would impact between 730 and 1000 acres of wetland habitat in Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the L-Pond, between 605 and 875 acres of these wetlands in Steel Creek below the embankment and the Savannah River swamp would reinitiate a successional recovery.

I.1.4.2 Recirculation through creation of Kal Pond

This alternative would create one large recirculating lake to cool both K- and L-Reactors. Constructing dams across both Steel Creek and Pen Branch would inundate approximately 2620 acres of floodplain, bottomland hardwood forest, and upland conifers. This would include 7.2 kilometers along Pen Branch, 7.6 kilometers along Steel Creek, and 4.0 kilometers on Indian Grave Branch. This impoundment would flood forested habitats that once contained the endangered red-cockaded woodpecker, and would eliminate some alligator habitat. The wetlands that would be impacted by this alternative are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

Maximum summer discharge temperatures would be about 33°C, but typically would be less. At the Steel Creek and Pen Branch deltas, near ambient water temperatures would exist. Little or no change is expected in the erosion or sedimentation patterns in Steel Creek or Pen Branch because the overflow, about 0.5 cubic meter per second to each creek, would not produce large increases to the normal flows of these streams. Both deltas should remain unchanged.

Kal Pond, which is expected to show thermal behavior much like that of Par Pond, is expected to have adverse impacts on approximately 615 acres of wetlands. However, because it would terminate the existing thermal effluent down Pen Branch, approximately 1170 acres of swamp could undergo successional recovery.

The creation of Kal Pond before restart occurs would eliminate thermal discharges to Steel Creek; approximately 650 to 920 acres of wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would be allowed to remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor. However, about 425 acres of wetlands along Indian Grave Branch and Pen Branch and 2005 acres of uplands would be adversely affected. In addition, the lake would allow approximately 1170 acres of previously disturbed wetlands to recover because the thermal effluent down Pen Branch from K-Reactor would be eliminated.

Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of Kal Pond, the wetlands below the dam in the Steel Creek and Pen Branch floodplain and the Savannah River swamp would reinitiate a successional recovery.

I.1.4.3 Recirculation through creation of High-Level Pond

Two dam sites on the Pen Branch drainage area north of L-Reactor have been studied for creating a recirculating High-Level Pond. The first and second dam sites would create pond areas of approximately 1225 and 1785 acres, respectively. This area of upland forest habitat, including 9.4 kilometers of Pen Branch which has not previously received thermal effluent, would be inundated. Thermal discharges (about 0.5 cubic meters per second) could reach 36°C under adverse summer conditions, but would average 34°C in the summer. Near-ambient temperatures would occur at the Steel Creek delta.

Approximately 610 acres of wetlands associated with upper tributaries of Pen Branch and 1175 acres of uplands are expected to be adversely impacted. This alternative would not adversely affect endangered species. After construction of the impoundment, a portion of Pen Branch would remain between the High-Level Pond and the thermally-impacted reach below K-Reactor. However, surviving fishes in this segment would become essentially landlocked; their access to upstream portions would be precluded by the dam and their access to downstream portions and the floodplain swamp would be limited to periods when K-Reactor is shut down.

The creation of a High-Level Pond before L-Reactor restart would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of

wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would remain in post-thermal recovery.

If this alternative is implemented before restart occurs, the environmental impacts would be as described above. Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands in Steel Creek, Steel Creek delta, and Savannah River floodplain plus 1175 acres of uplands and 610 acres of wetlands in upper Pen Branch. After the completion of the High-Level Pond, wetlands in the Steel Creek and Savannah River swamp could reinitiate a successional recovery.

I.1.4.4 Recirculation through Par Pond

Under this alternative, Par Pond would be used to cool the effluent from both P- and L-Reactors. A new pipeline would run northeast from L-Area and discharge into an excavated canal that would connect to Pond A near the R-Reactor effluent canal. From this point, the cooling water from L-Reactor would follow the same path through Par Pond that R-Reactor cooling water followed when that reactor was active. A new underground return pipeline would be constructed from near P-Reactor to the L-Reactor reservoir.

Because Par Pond already exists, any modifications of terrestrial habitat would be limited to a temporary disturbance to approximately 50 acres to construct the new discharge canal. This 2700-acre pond, however, contains a diversified and abundant assemblage of aquatic and semiaquatic biota, including more than 100 American alligators (Murphy, 1981). Based on previous thermal conditions when two reactors were operating, this alternative should not greatly increase water temperatures in the pond as a whole. However, a few acres of wetland habitat adjacent to Ponds A and B and the North Arm of Par Pond would be adversely impacted; some revegetation has occurred along the edges of these bodies since R-Reactor was shut down. This alternative would affect the alligator and aquatic biota through reduction in available habitat and avoidance of the heated effluent, primarily in the North Arm of Par Pond. Under adverse summer conditions, the discharge from Par Pond, about 0.5 cubic meters per minute could reach 33°C, but average summer discharges would be 31°C. Near-ambient temperatures would exist at Steel Creek delta.

The implementation of the Par Pond alternative before restart would eliminate thermal discharges to Steel Creek. Therefore, between 730 and 1000 acres of wetlands in the Steel Creek, Steel Creek delta, and Savannah River floodplain would not be impacted and would be allowed to remain in post-thermal recovery, unaffected by cooling-water effluents from L-Reactor.

Implementation after restart occurs would impact between 730 and 1000 acres of previously affected wetlands and wetland habitat in the Steel Creek, Steel Creek delta, and Savannah River floodplain. After the completion of the Par Pond diversion, the wetlands in the Steel Creek and the Savannah River swamp system would reinitiate a successional recovery.

I.1.5 Other alternatives

I.1.5.1 Thermal cogeneration

Although a feasibility study of various cogeneration options has not been completed, it is anticipated that the most effective use of waste heat would involve utilization of the reactor thermal effluent as a heat source. The use of a Rankine cycle would cool the reactor thermal effluent from 71°C to 49°C. However, three to five times the flow of reactor thermal effluent would be required to cool the condenser in the Rankine cycle and would result in a temperature increase to 3° to 6°C to the ambient-temperature water used for cooling. Thus, approximately 58 cubic meters per second of cooling water will be discharged to Steel Creek at a temperature of about 49°C.

The temperature reduction of thermal effluent would probably be offset by the increased flows and water fluctuation levels to Steel Creek from the Rankine cycle coolant. The expected loss of wetlands would be significantly greater than direct discharge due to the major increase in flow, flow fluctuations, and increased sedimentation, rather than temperature effects.

The principal difference in the implementation of a thermal cogeneration system using the Rankine cycle before or after L-Reactor restart would be the rates of vegetative mortality due to thermal effects versus flow effects.

I.1.5.2 Low-head hydropower

The implementation of a low-head hydropower option either at the L-Reactor outfall or below a 500-acre impoundment would not significantly alter wetland effects, as described either for discharge to Steel Creek (Section I.1.1.1) or for direct discharge to a 500-acre lake (Section I.1.3.2).

I.1.5.3 Modified reactor operation

The total heat load discharged into Steel Creek is a direct function of reactor power. Therefore, power could, in theory, be limited to a level below that achieved at normal operating limits to control this heat load. If the power were reduced, cooling-water flow could also be set to reduce either the total flow or the temperature of Steel Creek. This alternative could be used in combination with other alternatives to reduce heat loading.

As power is reduced, the temperature (under extreme summer conditions) is reduced from 80°C at the outfall at 2400 megawatts thermal to 71°C at 2000 megawatts thermal, to 53°C at 1200 megawatts thermal and to 40°C at 600 megawatts thermal. Temperatures within the Steel Creek system are also affected by reactor power levels. The temperature experiences at various locations below the outfall are presented in Table 4-36.

Under generating levels of 600 megawatts thermal, 30°C is reached prior to entry to the Savannah River. Further temperature reduction in the Savannah River would require simultaneous reduction in power and flow (see Figure 4-2).

This simultaneous reduction would increase the outfall temperatures higher than those reported above and, therefore, offer little benefit to the upper portions of Steel Creek. Although some thermal mitigation is achieved in the swamp, flooding, fluctuating water levels and siltation impacts would still result during periods of reduced power. Therefore, about 730 to 1000 acres of previously impacted wetlands that are beginning a successional recovery would again be affected.

While low power operation is not practical for extended periods of time, it can provide a means of meeting thermal limitations for short periods. The potential reduction of reactor power to reduce the cooling-water temperature is directed at ensuring a sufficient zone of passage in the Savannah River. However, at reduced power, production efficiency would be reduced.

Under extreme meteorological conditions, reducing power by a factor of four could reduce the temperature of the effluent entering the swamp by about 10°C and reduce the creek-to-river delta-T by about 3°C.

I.1.5.4 Fisheries management programs

The direct discharge of L-Reactor cooling water to Steel Creek with fish management programs would essentially have the same wetland impacts as those described in Section I.1.1. Between 730 and 1000 acres of previously impacted wetlands that are beginning a successional recovery would again be impacted.

No designs or site selection for an onsite hatchery facility and rearing ponds have been made. If a hatchery and rearing ponds were established onsite, their construction would occur in upland areas or existing facilities would be used. Therefore, the only impact to wetlands in addition to that from a direct discharge would be the possible construction of an outfall from a wastewater treatment lagoon that might be required for rearing-pond effluent.

The implementation of fish management programs would provide a partial replacement for the productivity of wetland habitat and Steel Creek and Savannah River swamp spawning areas that would be lost due to the resumption of direct discharge.

I.1.5.5 Protect similar wetlands

If available, a property comparable in size and wetlands value to the impacted Steel Creek/swamp area could be designated on SRP or purchased and set aside as a fisheries/wildlife preserve. Thermal discharges from L-Reactor could reduce the spawning/rearing habitat currently utilized by fish species in the Steel Creek/swamp system. Other creeks and associated wetlands with similar spawning/rearing habitat exist between the New Savannah Bluff Lock and Dam and the lower tidal reaches of the Savannah River. A large parcel of land (greater than 1000 acres) would cost approximately \$500 per acre.

1.2 FLOODPLAINS

Several of the alternative cooling systems require the construction of dams or structures in the floodplains of streams (Steel Creek, Pen Branch, Indian Grave Branch, and Meyers Branch) on the Savannah River Plant. Because these dams or structures must direct or use onsite streams to achieve a reduction in thermal or flow effects, locating them outside the floodplain would not be possible.

The construction and operation of dams or structures on SRP streams would, to the maximum extent possible, avoid adverse impacts associated with the use and modification of the floodplain for the following reasons:

- There would be no appreciable modification of water levels or flow regimes in offsite streams and rivers. Thus, the natural and beneficial values of offsite floodplains would be maintained.
- If the onsite floodplains were flooded, the dams and structures would not create additional consequences to any emergency conditions.
- Access to the Savannah River Plant is strictly controlled; no dwellings, hospitals, schools, nursing homes, or other structures are located within the floodplain. Thus, no individuals or private property would be affected.
- No essential and irreplaceable records, utilities, and/or emergency services would be affected or lost in the event of flooding.

Impacts to water quality and ground water, archeological sites, wildlife habitat, and other resource uses were described in Section 1.2 and in Section 4.4.2.

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APPENDIX J

SRP REACTOR SAFETY EVOLUTION*

INTRODUCTION

The Savannah River Plant reactors have operated for over 115 reactor years without an incident of significant consequence to on or off-site personnel. The reactor safety posture incorporates a conservative, failure-tolerant design; extensive administrative controls carried out through detailed operating and emergency written procedures; and multiple engineered safety systems backed by comprehensive safety analyses, adapting through the years as operating experience, changes in reactor operational modes, equipment modernization, and experience in the nuclear power industry suggested. Independent technical reviews and audits as well as a strong organizational structure also contribute to the defense-in-depth safety posture. A complete review of safety history would discuss all of the above contributors and the interplay of roles. This appendix, however, is limited to evolution of the engineered safety features and some of the supporting analyses.

The discussion of safety history is divided into finite periods of operating history for preservation of historical perspective and ease of understanding by the reader. Programs in progress are also included.

The accident at Three Mile Island was assessed for its safety implications to SRP operation. Resulting recommendations and their current status are discussed separately at the end of the appendix.

SUMMARY

Operation of the Savannah River reactors began in 1953 with a conservative design, automatic shutdown systems, and detailed written procedures. As reactor safety technology advanced at Savannah River and in the U.S. nuclear industry, as modernized equipment (e.g., computers) became available, and as operating experience and comparison to industry standards suggested needs for change, projects were undertaken to upgrade and supplement existing safety systems.

Confinement

Original control of airborne radioactive releases was by dispersion via a tall stack. Confinement features were added beginning in 1960 to cope with the very low probability accidents that could release radioactive materials. The features include filtration of all the ventilating air leaving the reactor building using moisture separators, particulate filters and halogen adsorbers (carbon).

*This appendix, in its entirety, is derived from: Rankin, D.B., 1983. SRP Reactor Safety Evolution, DPST-83-718, E. I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken, South Carolina.

Emergency Cooling and Liquid Activity Containment

The original design provided for emergency manual addition of light water to the reactor core with retention of the water in a dedicated tank after it leaves the building. Improved sources of light water and a common pressurized addition header were added in the mid 60s. Automatic emergency cooling was provided beginning in 1973 with many additional system improvements toward increased reliability being made over the years. Larger contaminated water removal pumps and increased storage capacity were added beginning in 1973.

Computer Monitoring and Control

Safety of reactor operation was enhanced beginning in 1964 by computer monitoring of critical process conditions and in 1970 by computer control of reactor operating and shutdown systems. Updated redundant control computers replaced the original ones in 1978 and redundant "safety" computers were installed for assembly temperature and flow scram protection.

Automatic Emergency Shutdown

The original instrumentation provided numerous monitoring circuits which could actuate the safety rods to drop if prescribed limits were exceeded. Safety rod system improvements over the years provided diverse relay logic and paths for scram signals, utilizing both AC and DC power sources. A backup shutdown system, the Supplementary Safety System, was added in 1957 to provide for manual injection of a liquid neutron poison in the event the safety rods failed to drop. The Gang temperature monitor automated this system in 1974 to be actuated upon sensing of very high temperatures. The Safety Computers were programmed beginning in 1979 to back up scrams with SSS actuation, providing protection for all postulated transients.

Seismic Protection

Seismic scram protection was provided in 1955. As a result of earthquake and building structural analyses, seismic bracing was added beginning in 1976 to protect the susceptible building structures and emergency cooling system piping from postulated credible earthquakes.

Fuel Handling

Fuel handling operations improvements in the late 70s and 80s have equipped the charge and discharge machines with computer positioning and misload protection as well as assembly identification capability. Automatic cooling for all irradiated assemblies was provided to the discharge machines.

Programs In Progress

Programs are currently in progress to assess possible improvements to the confinement system, emergency cooling system and fuel handling equipment and to provide additional seismic analyses for critical systems. In addition, Savannah River Laboratory performs continuing research and development in all areas of reactor safety. And their detailed review of plant operations and programs provides a strong independent safety overview as outlined in the Nuclear Safety Control Procedures.

In addition, an extensive program is currently in effect to incorporate lessons learned from the Three Mile Island accident into the SRP reactor safety features. Numerous changes have been incorporated into the SRP operations and others are in progress related to this program. Computerized diagnosis of multiple alarm situations and availability monitoring of critical equipment are two of the programs in progress.

Figure J-1 presents safety milestones from initial startup to present.

DISCUSSION

1953-1960

The original design concept of the SRP reactors envisioned the prevention of accidents by backup equipment, comprehensive instrumentation, detailed written procedures, well-trained personnel and strong technical backup. Additional safeguards were provided by an isolated site to protect neighboring people, by reactor buildings designed to resist pressures from external blasts, and by exhausting the building air through a high stack for increased dispersion of hazardous airborne contamination.

The earliest formal safety analysis report for SRP reactors was issued in April 1953; inherent reactor hazards and postulated accident scenarios were discussed and the initial facility design features protective of such accidents and mitigative of the consequences were presented.

Original design features directly related to reactor safety (and maintained in similar form to present) are listed below. These formed the "building blocks" for later improvements.

- Safety rod system - Sixty-six cadmium safety rods (79 in C-Reactor) are provided in 1-inch positions interstitial to fuel positions throughout the reactor. The rods are suspended just above the reactor core and will reach their full IN position and shut down the chain reaction about 1 second after a scram demand signal. Original circuits capable of initiating safety rod (scram) action are discussed later.
- Control rod system - Sixty-one control rod bundles (73 in C-Reactor), housing seven control rods each, occupy 4-inch lattice positions in the central portions of the reactor. A combination in each bundle of half-length and full-length (effective portions) rods provides for detailed axial and radial flux control, thus minimizing hot spots and the resultant challenge to assembly cladding and providing for overall power optimization. The control rods are capable of shutting down the reactor and maintaining it subcritical, independent of the safety rods.
- Cooling system - 6 D₂O coolant pumps powered by 3000 HP a.c. motors and backed up by 120 HP d.c. motors originally provided the capability of circulating about 78,000 gpm of assembly coolant. The online (via gear reducers) d.c. motors provided 24,000 gpm capability to remove shutdown decay heat. About 67,000 gpm of Savannah River water provided cooling for the primary loop (D₂O) through 6 heat exchangers.

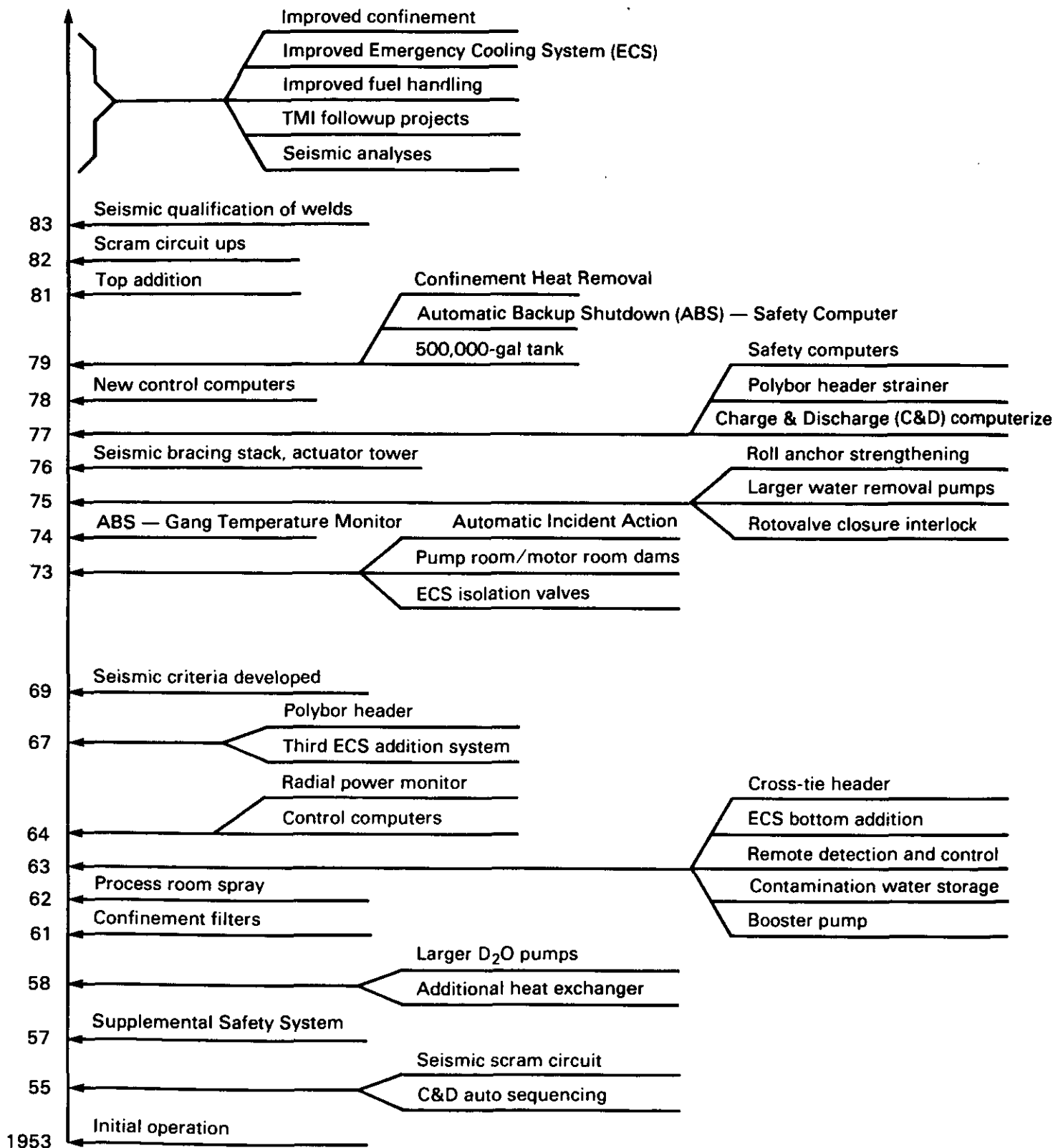


Figure J-1. Reactor safety milestones.

- Shielding - More dedicated to personnel safety than reactor safety, top, bottom and thermal circulating deionized water shields were provided for radiation shielding and removal of heat from neutron and gamma attenuation. Seven feet of concrete immediately surround the thermal shield. The walls, floors, and ceilings of the pump rooms, motor rooms, and heat exchanger rooms are constructed with a minimum of 4 ft of concrete for shielding.
- Instrumentation - Instruments primarily concerned with reactor safety are those that monitor neutron flux in the reactor and cooling system parameters such as activity, temperature and pressure at various points in the system. The original "action-oriented" instrumentation was divided into 4 modes:
 - (1) Scram I - energized the safety and control systems, causing reactor shutdown within about 1 second.
 - (2) Scram II - energized the scram circuit on the control rod system only, causing reactor shutdown within about 2 minutes. More rapid shutdown was not deemed necessary for these events to justify the thermal transient caused by safety rod action.
 - (3) Reversal - caused control rods to be driven into the reactor in the normal sequencing pattern. This slow reduction in power allowed time for correction of less threatening problems with possible return to standard operation without shutdown.
 - (4) Annunciators - provided audible and visual indication of abnormal signals. Items causing scram or reversal action as well as numerous process variables were annunciated.

Original items monitored for scram and/or reversal action included:

- Neutron flux level
- Reactor period
- Temperature of D₂O effluent from assemblies
- D₂O plenum pressure
- D₂O pump motor failure
- Heat exchanger H₂O cooling water flow low
- Shield flow low

- Fuel Handling

A charge machine is provided to charge fuel from the assembly area presentation point to the reactor; the discharge machine removes heat-generating irradiated assemblies from the reactor and transports them to the disassembly area canal. All operations are conducted in air. The charge and discharge machines and associated equipment were provided several safety features to prevent erroneous loading and irradiated assembly overheating. Protection included:

- (1) Redundancy of charge and discharge cranes to be able to handle one another's functions.

- (2) Ability to discharge housing (with assembly) quickly should sticking of an assembly occur.
- (3) D₂O and H₂O coolant supplies to an assembly if discharge required longer than 2 minutes.
- (4) Protection against charging to a position already filled.
- (5) Anti-collision devices for the machines.
- (6) Remote position indicators to operators in the crane control room.

Accidents Considered

The 1953 safety analyses hypothesized two basic accidents: 1) a "boiling accident" caused by complete stoppage of D₂O and H₂O flow by external forces (e.g., earthquake) and 2) a prompt criticality. Offsite doses were calculated to be less than the lethal range for the boiling accident with 10% fission product inventory release. At that time, no credible mechanism for a prompt criticality was determined to exist. Accident scenarios considered for dose calculation were expanded by 1956 to include fuel loading errors, the loss of D₂O circulation accident by system failures, and prompt criticality from startup accidents. Maximum offsite dose from the loss-of-circulation accident were calculated to be in the lethal range.

Administrative Controls

In addition to safety circuits and systems provided in the original facility, a set of detailed written operating instructions governed each step in the process of charging, startup, operation, shutdown and discharge of the reactor. Emergency procedures were provided to respond to conditions necessitating a reactor shutdown. Technical Standards, based on Technical Manual specifications, prescribed limits of operation. Test Authorizations were provided for any changes in operating mode.

Emergency Cooling

In response to postulated loss of D₂O flow incidents, a system was provided for manual addition of H₂O to the reactor. Cooling water lines were provided, with manual activation through remotely operable gate valves.

Seismic

A seismic scram circuit was installed in 1955 to ensure reactor shutdown in the event of an earthquake.

Backup Shutdown Systems

The original safety feature for terminating a power transient if the safety rod system failed was via a moderator dump to dedicated storage tanks. Manual actuation of H₂O addition following the moderator dump would have provided for decay heat removal. The Supplementary Safety System was installed in 1957 to provide for manual reactor shutdown via a liquid neutron poison injection should the safety rods fail to drop during a power rise transient.

The year 1958 was a significant one in both production-oriented facility changes and increased safety effort. New, larger D₂O pumps were installed to increase flow capacity to about 150,000 gpm. An additional heat exchanger was installed in each of the pumping systems in parallel with the existing exchanger. The resultant reactor power increase (to approximately 2000 MW) brought higher individual assembly powers and reactor fission product inventory and thus increased concerns on reactor safety issues. Accidents considered increased to include power surge mechanisms, the "cold-water accident" because of the negative temperature coefficient, loss of coolant, and single assembly melting during operation or discharge. Technical studies produced limits on the heat flux of individual assemblies to prevent cladding "burnout." Tests were proposed to determine the disposition of melted fuel; and reactor containment was first considered.

Fuel Handling

In 1955, primary operations of the charge and discharge machines were provided with the capability to automatically sequence through most steps in the operations without manual input after each step. This "auto cycle" feature significantly reduced the amount of operator input necessary and thus increased system reliability.

External Review

An integral part of the SRP safety philosophy is review by external technical experts. The Atomic Energy Commission Advisory Committee on Reactor Safeguards (ACRS) performed an extensive review in 1958 and concluded:

"The buildings in which the SR reactors are housed do not possess any significant containment features, such as those now being provided for power reactors located in more populated areas. In the event of a serious accident that would breach the reactor tank and shield, the building shell in itself could not be expected to provide a third line of defense of any consequence on restraining the volatile fission products."

It was recommended "that the Du Pont Company explore alternative paths toward obtaining a higher degree of confinement that is now in effect."

The combination of internal and external review led to a significant increase in safety studies. Primary proposals for partial containment included building sealing and exhaust air filtration.

1960-1965

Confinement System

Containment of fuel melt releases continued to dominate the safety considerations during the early 60s. In 1960-1961, a major improvement project provided moisture separators, particulate filters, and halogen adsorbers (carbon) in the process area ventilation exhaust stream to remove airborne contamination, particularly I¹³¹. A backup motor with independent power supply was added to each exhaust fan. Figure J-2 shows the ventilation/confinement system arrangement. The reactor room and process areas were sealed to minimize leakage

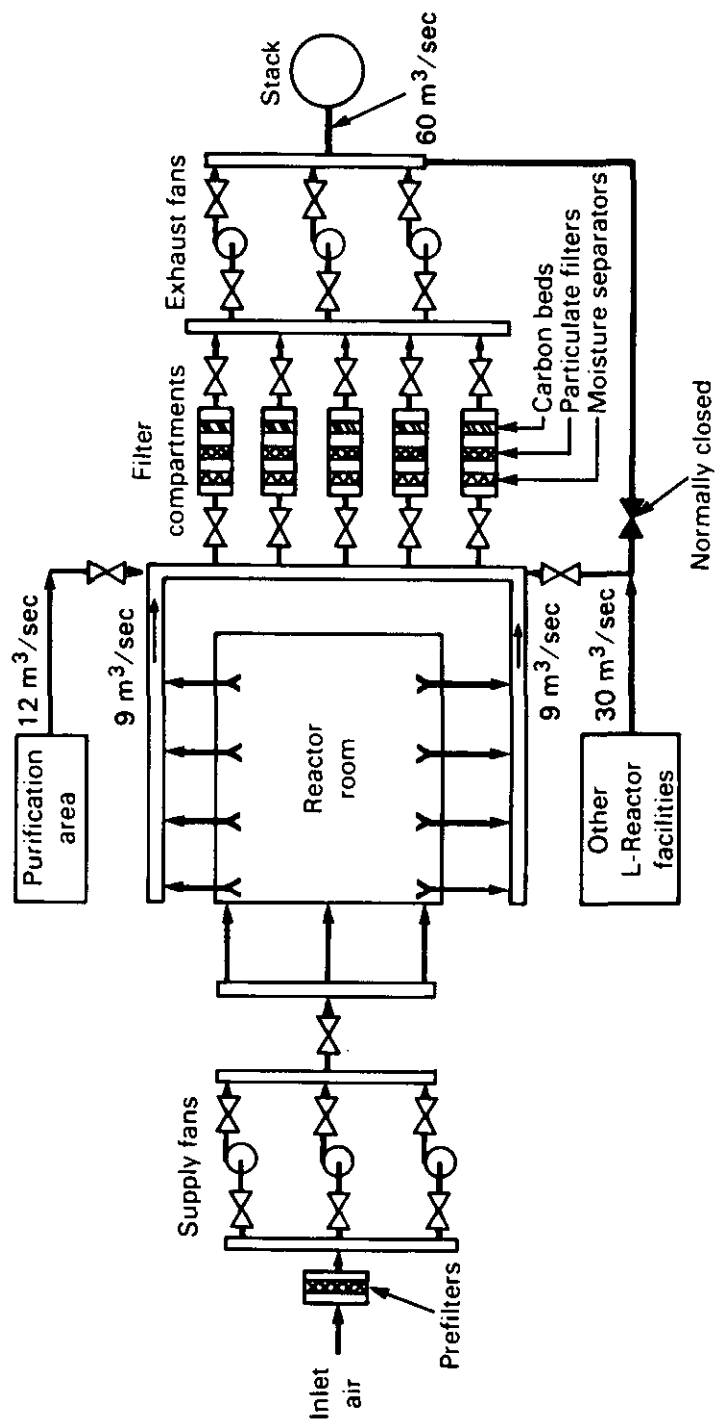


Figure J-2. Flow diagram of reactor ventilation system.

outside the confinement path. The improved system was expected to retain 99% of released particulate activity and 99.9% of the halogens.

ECS

The emergency cooling system received considerable upgrade in 1962-1963. Light water addition lines were tied together by a common "cross-tie header" to facilitate maintaining a pressurized line for monitoring system availability. Piping was redesigned to provide addition through either the top addition or the bottom addition. Submersible addition valves (89-299 series) were installed to maintain addition capability should the -20 ft, -40 ft building area flood. And the booster pump was added to increase the source flow capability and number of sources of light water.

The Remote Detection and Control (REDAC) system was provided to be able to monitor system parameters remotely and add light water if necessary after an area evacuation was required. Also, a 50-million gallon earthen basin was provided to contain contaminated water that would result from a loss of cooling or loss of circulation accident with ECS actuation.

Computers

Reactor monitoring and consequently safety was enhanced in 1964 by providing computer monitoring of critical process conditions. A GE-412 computer was installed in each control room for improved reactor temperature monitoring, calculation of the proximity to cladding burnout and better operating analysis. The computers were provided with control rod reversal capability if assembly operating temperatures increased to 1°C above prescribed thermal-hydraulic operating temperature limits. This reversal capacity prevented minor excursions from reaching the point where scram circuits were challenged.

Fuel Handling

A spray system was added to the reactor room in 1962 for cooling an irradiated assembly if dropped on the floor during discharge operations. The system consists of a header with 12 groups of fixed spray nozzles mounted on the reactor room wall. The spray pattern from the nozzles covers the area traversed by the discharge machine.

Many improvements were added to the charge and discharge machines in 1963. The ability to separately hold (chuck) both components of an assembly having separately dischargeable components ("double chucking") and a sleeve to hold down one while discharging the other were added. These features decreased the possibility of dropping components or of discharging one unintentionally with the other.

Emergency cooling for assemblies during discharge was enhanced by providing automatic sequencing to the secondary source if the primary source fails. Also, the distribution of flow to an assembly was improved by providing a better path into the top of the assembly.

An emergency shear was provided for cutting off the top portion of failed assemblies to facilitate enclosure in a failed assembly container (HARP).

Electrical Distribution System

The original supply of power to building equipment was distributed from four transformer rooms located within the reactor building. A fifth distribution station, known as the containment substation, was added in the early 60s and placed above ground level outside the building. This station will provide power to critical equipment in the event that flooding of the below-grade elevation disables the normal supply.

General

The number and type of accidents analyzed was expanded during this period to include anticipated transients without scram (ATWS). As a result, reactor operating restrictions on temperature and power were imposed in 1964. The radial power monitors (RPMs) were installed to provide scram protection for cluster (group of 6) and gang (group of clusters) temperature increases. And the maximum control rod drives speed was reduced to limit the power increase from a rod driveout accident. Explosive valves were added to the ink injection system to increase the reliability and speed of injection should the safety rods fail to drop.

Reactor power was increased several hundred MW in 1963 when operations with 5 PSIG blanket gas were established. R-Reactor operation was discontinued in 1964 due to reduced product demand.

1965-1970

ECS

In 1967, the bottom addition system was moved so that three systems now had addition capability. This increased capacity was designed to limit core damage to less than 1% for the worst-case loss of coolant accident as well as to provide additional redundancy. Also, it was recognized that the cold H₂O which the ECS would add to the reactor could produce, for current charges, a positive reactivity transient which may override the effect of safety rod insertion. So a 20,000 gallon storage header was added in line with the crosstie header and filled with a neutron poison solution (2% polyborate), sufficient to preclude a positive reactivity transient from either necessary or unwanted ECS actuation.

Seismic

The blast criteria used in the original design did not necessarily provide for the effects of earthquakes. The buildings were very resistant to external forces but their response to dynamic effects was not specifically analyzed at the time of the original design. The reactor building structures were analyzed in 1969 for their response to seismic criteria developed by Dr. George Housner of the California Institute of Technology. The structural analysis was made by John A. Blume and Associates of San Francisco. These independent consultants recommended a set of seismic criteria for the design and analysis of retrofitted SRP facilities. Reactor area buildings and associated systems and equipment were then classified according to their required seismic resistance. The classification applies to those features of each system that are essential to protect the public health and safety. The results of the studies concluded that remedial strengthening of the actuator towers and exhaust stacks was necessary

to comply with the criteria. Resultant projects are discussed later in this report. Process water piping was determined to be adequately resistant to seismic stresses.

Other

Because the SRP reactors operated before formalized nuclear industry guides and standards existed, building design and construction did not necessarily conform to the later criteria. The first comprehensive, documented comparison of SRP reactors to licensed reactors was issued in 1967 after the AEC had issued a set of 70 criteria for licensees. Exact comparison with the criteria were made where system characteristics were similar; where exact comparison was not practical, an effort was made to define the intent of the criteria with respect to the SRP facilities and discuss compliance as appropriate. It was concluded "that the SRP reactors meet the overall intent of the 70 Criteria and, in most cases, meet the literally interpreted criteria."

L-Reactor operation was discontinued in 1968 due to decreased product demand.

1970-1975

Confinement System

A new carbon test facility was placed in operation for evaluating aging effects on carbon and other filter components.

ECS

Isolation valves were installed (1973 in P and K, 1974 in C) in each of the four ECW sources converging into the common polyborate storage header. This isolation limits the volume of water available to the storage header to prevent flooding of D₂O pump motors in the event of header failure. Such a failure without isolation would both produce the need for ECW addition and defeat the protection. The isolation valves are normally closed and would be opened automatically upon ECS actuation.

Also to preclude flooding of circulating pump motors from any cooling water leak or ECS actuation, four new sump pumps (2 rated at 4500 gpm; 2 at 2500 gpm) were installed in 1975 to replace the original pair of 2000-gpm pumps. The 2500-gpm pumps are submersible. The total 14,000 gpm removal capacity is capable of removing all ECS water even if all three addition systems were on-line.

A new hydro-starter was installed on the booster pump (one of the four ECW sources) after a history of minor starting problems. The original electric starter was maintained as a backup.

Remote start capability for the main cooling water pumps was provided to the central control room in 1973. These pumps could originally be shut off remotely to control a large cooling water leak. This ability to start the pumps provided greater assurance of ECW supply if light water addition were necessary during reactor shutdown while some of the pumps were off-line.

Thirty-six inch high dams were installed in the -40 ft level between the pump room and motor rooms in 1973-1974 to prevent a D₂O leak with ECS actuation from causing flooding of the D₂O pump motors. A one-way (motor room-to-pump room) gate was installed in the dam to allow flow from a postulated cooling water line break to reach the pump room sump pumps and take advantage of their removal capacity. The gate capacity was designed to match the sump pump capacity.

Automatic Incident Action

The capability for light water addition in the event of a large D₂O leak was automated beginning in 1973. The M-2 Automatic Incident Actuation (AIA) consoles contain electronic logic circuitry which utilizes two-out-of-three vote logic from in-reactor level sensors to determine the need for ECS actuation. Three types of liquid-level sensors, including absolute-pressure sensors, differential-pressure sensors, and conductivity cells, are used to provide protection from common mode or common cause sensor failure mechanisms. The system is self-bypassed for leaks of less than 1800 gpm.

System functions initiated by Incident Action originally included the following:

- Starting of the booster pump
- Opening of all ECW header isolation valves and supply valves for the two top addition systems
- Energizing of bottom addition supply valve circuitry to open on level control
- Set up of the ventilation/confinement system for optimum effectiveness

An interlock circuit was added in 1974-1975 to provide automatic closure of rotovalves (to prevent backflow of ECW through heat exchangers) in the two top addition system.

Roll Anchor Modification

An analysis of emergency cooling water hydraulic forces indicated that strengthening of the roll anchor stands for the plenum inlet lines was required in the three reactor areas. If ECS water were added to a full reactor tank through both top addition systems concurrently, the pressure generated under the top shield could have caused failure of the roll anchors. Roll anchor modifications were completed about 1975.

Computers

During 1970-1971, the online computers were modified to perform closed-loop control of the reactors in addition to the monitoring and rod reversal functions. Direct control was accomplished by adjusting control rod settings with stepping motors to control overall power level and selectively move rods for most effective power generation within the various reactor regions. The GE-412 computers remained online 99% of the time and controlled power ascension and level power as well as radial and axial flux shapes.

Backup Shutdown System

Supplementary Safety System

Piping modifications were made to reduce the SSS response time (time interval between system actuation and arrival of gadolinium nitrate "ink" in the reactor). The modifications reduced the response time from 6 seconds to 0.7 seconds. Replacement of all SSS explosive valves with an improved design increased system reliability.

Automatic Backup Shutdown

The first of the Automatic Backup Shutdown (ABS) systems was installed in 1974 and called the Gang Temperature Monitor (GTM). The GTM is completely independent of the safety rod shutdown system. It actuates the SSS to inject gadolinium nitrate into the reactor tank when the coolant effluent temperatures of selected assemblies exceed prescribed limits. Specific incidents for which the ABS-GTM can provide protection are the gang (control) rod withdrawal and the total loss of AC pumping power without scram. The ABS-GTM provides a diverse reactor shutdown channel, and therefore, increases the overall reliability of reactor shutdown protection. No mechanism has been identified that could cause a common mode failure of both the safety rod and ABS GTM systems.

Seismic

The large process heat exchangers are mounted on railroad-car-type wheels and were recognized as susceptible to movement from seismic activity. The exchangers were braced in 1974 to preclude such movement which could damage the attached cooling or process water piping.

1975-1980

Confinement System

Type GX-176 coimpregnated (potassium iodide and triethylene diamine (IEDA)) carbon was installed in all three reactor confinement systems in 1976 to replace Type 416 unimpregnated carbon. Type GX-176 carbon retains organic iodides better than Type 416.

Studies begun in the early 1960s recognized the threat of overheating of the carbon filters from airborne fission product particles in the event of extensive core melting. Such overheating would seriously reduce the iodine-retention capacity of the carbon and even cause desorption of the collected iodine. The studies and possible solutions were refined through the years and culminated in 1979 with installation of the Confinement Heat Removal (CHR) System. The CHR system is designed to flood the building -40 ft level pump room floor with water in the event of a full-core meltdown in which molten core breaches the tank bottom and is deposited on the floor. The water would maintain air temperatures low enough to prevent failure of the confinement system filters. The water is supplied from the disassembly basin through two redundant pneumatic valves. The system is manually actuated from a dedicated console in the central control room when alarms indicate (1) both a large airborne activity release and reactor tank bottom temperature greater than 232°C at one of three

reactor positions where heat sensors are located or (2) temperatures greater than 232°C at any two of the three reactor positions containing heat sensors. The heat sensors are in dedicated monitor pins in three blanket (outer ring) positions in the reactor.

The CHR system design provides for both automatic and manual actuation of the pneumatic valves. Initially, only the manual mode was made operational. Future plans call for activation of the automatic mode after reliability studies are completed.

ECS

Prior to 1977, the river water supply line was considered the primary source of emergency light water cooling supply because of its independence from the 186 cooling water supply basin and pumps. However, flushing tests in 1977 identified significant debris (leaves, sticks, clams, etc.) which could become lodged in reactor assembly flow channels and reduce the cooling capability. So this line was valved off as a primary source and assigned backup status. In 1978, the maintenance pressure for this line was reduced to 20 PSIG and the source is available as a last choice if the booster pump and both cooling water inlet headers fail.

The recognition of a debris problem prompted installation of a debris strainer in the polyborate storage header common to all ECS supply sources. Two redundant bypass check valves around the strainer are designed to open if debris pluggage of the strainer causes the strainer delta P to exceed prescribed limits.

Contaminated Water Storage Facilities

A 500,000 gallon storage tank and related piping were added to the 50,000,000 gallon contaminated water earthen storage basin beginning in 1979. Following a loss of coolant or loss of circulation accident with ECS actuation the first 60,000 gallons (approximate D₂O system capacity) will now flow to Building 106 and the next 500,000 gallons to the new storage tank which is vented back through the building ventilation/confinement system. Any remaining flow is diverted to the 50,000,000 gallon basin. These facilities assure that all expected radioactive releases from credible accidents would be contained within the filtered system. Figure J-3 shows the contaminated water removal facilities.

Computers

Control Computers

TE | The GE-412 process control computer in each area was replaced beginning in 1978 with two new Interdata-M70 computers (Reference 4). These computers, which are currently in use, perform basically the same functions as the GE-412 (e.g., monitoring of process data and performing closed-loop control operations). The two machines have identical capacity, but only one performs the primary functions at a given time; the other provides secondary data processing functions while in a standby status. Either is capable of performing all required on-line functions in the event one becomes unavailable.

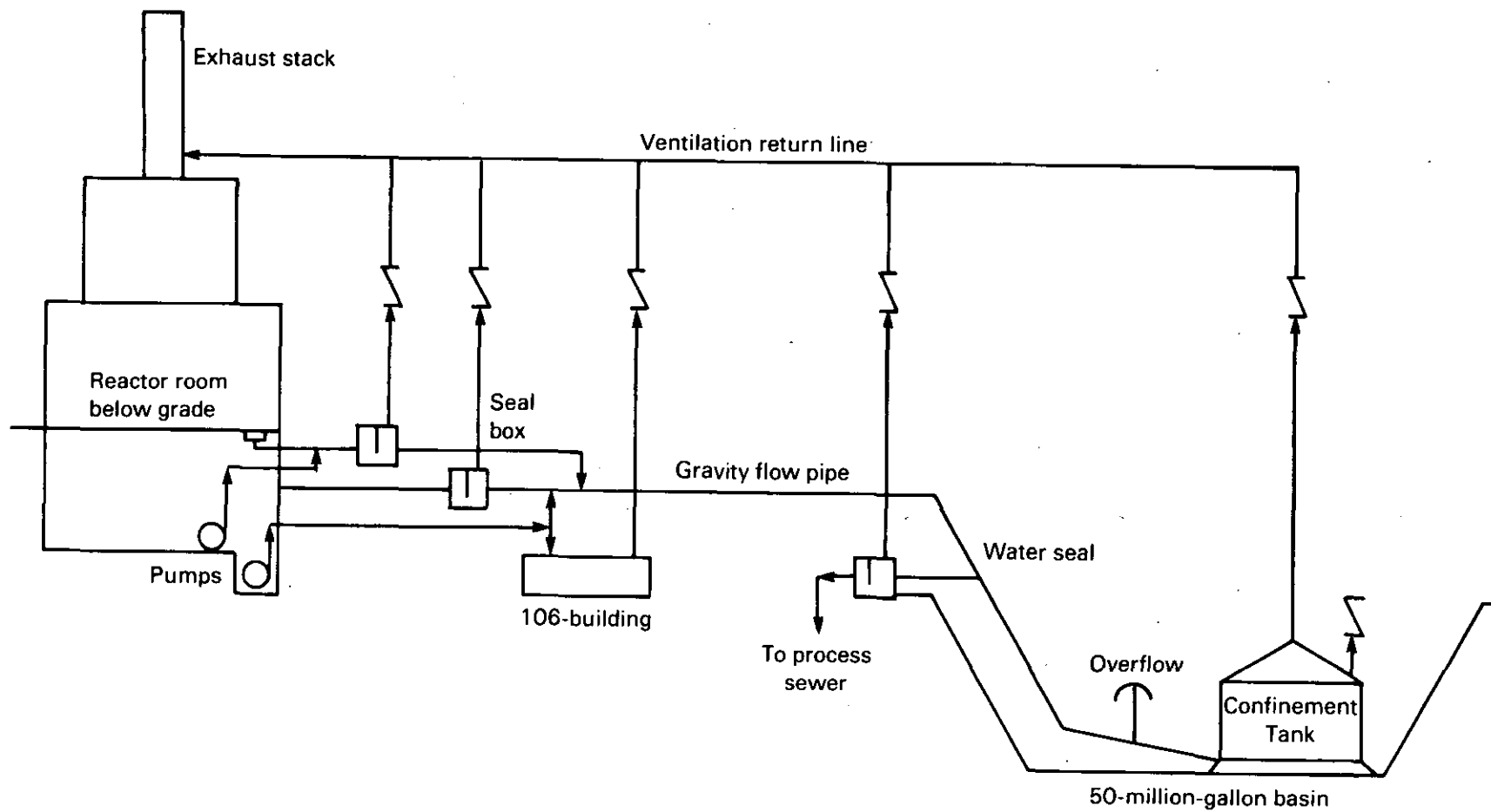


Figure J-3. Confinement tank.

TE | Improvements over the GE-412 monitoring include:

- (1) Faster scan of temperature input signals (approximately 30 seconds compared to the previous five minute scan period).
- (2) Monitoring continuity and continued control capability when one control system fails (only secondary data processing functions will be interrupted).
- (3) Improved input-output capability and more effective communication with reactor operator through cathode ray tube (CRT) displays.
- (4) Increased reliability (dual, redundant computers and improved methods for both hardware and programming fault detection).
- (5) Future applications (extra memory capacity for automatic alarm analysis and monitoring during reactor shutdown).

Safety Computers

In addition to the new process control computers, dual safety computers were installed in each area beginning in 1977 to provide scram protection from low flow or high temperatures in reactor assemblies. Prior to this, scram protection for high temperature was provided by the radial power monitor (RPM, installed 1964), which monitored the average temperature of groups of six assemblies versus prescribed scram setpoints. Flow protection had been provided by the Flow Monitor, a pressure switch safety circuit which shut down the reactor if any assembly monitor pin delta P dropped below prescribed setpoints. The safety computers offered the following major improvements over the RPM and Flow Monitor:

- (1) Overtemperature scram protection for all individual reactor positions rather than only clusters in the central 60%.
- (2) Rapid scan time. All temperatures are scanned each 0.36 second. Flows are scanned each 0.15 second.
- (3) Reduced dependence on manual operations such as setpoint adjustments and instrument bypass.
- (4) Ability to reject spurious signals.
- (5) Increased reliability through dual redundant computers, frequent internal operability testing, etc.
- (6) Replacement of obsolete flow sensors and instrumentation.
- (7) Future applications - capability for different levels of protective action, such as liquid reactor poison injection in addition to safety rod scram (ABS-SC, discussed below).

Automatic Backup Shutdown Using Safety Computers (ABS-SC)

Although the ABS-GTM provides diverse protection for certain anticipated transients without safety rod scram action, it was recognized that faster time response and more comprehensive protection was desired. The capability was added to the safety computers beginning in 1979 to back up the safety computer scram relays and supplement the safety rod scram action with automatic injection of the SSS poison (ink) if certain adverse conditions were detected. If reactor assembly effluent temperatures continue to increase or do not decrease sufficiently following scram initiation, ink will be injected. The system takes advantage of the existing redundancy of the Safety Computers since each computer can independently take ABS action.

An external review by qualified consultants in the industry confirmed the effectiveness of ABS-SC in coping with anticipated transients without safety rod scram action.

Fuel Handling

The charge and discharge machines were equipped beginning in 1977 with computerized positioning and fuel and target position identification. This greatly reduced the possibility for inadvertent criticality which might be caused by placing a fuel (^{235}U) in a target (^{238}U) position.

The assembly cooling system on the discharge machine was improved in 1978. Two independent sources of D_2O and two of H_2O were provided with automatic sequencing through their predescribed hierarchy. The supply for the sources was improved and in-line filters provided, and two methods of directing the water to the top of the assembly were provided. Monitoring of system flows and pressures was updated and expanded.

Seismic

Improvements were made beginning in 1976 to meet the seismic requirements for resistance to maximum predictable earthquakes. Projects included:

1. Strengthening the base of the actuator towers and eliminating the spring action of the supporting girders. The spring action increases the response of the tower to dynamic forces.
2. Strengthening the building exhaust stack.
3. Improving the lateral support for the emergency cooling system (ECS) piping and the supplementary safety system (SSS) piping.

1980-1983

ECS

Beginning in 1981, the bottom addition system was converted to a top addition system. Addition valves in each area were updated to a more reliable design.

Automatic Backup Shutdown

ABS-SC protection was expanded in 1982 to provide for backup ink injection for all scram circuits. New digital inputs inform the computers of the current status (bypassed, online, actuated) of all other safety circuit relays. When any safety circuit calls for scram action, the safety computers back up the signal using their own "echo scram" relays. Then an immediate assessment of reactor temperature conditions determines if ink injection is required to achieve sufficient reactor shutdown.

Uninterruptible Power Supplies for Scram Circuits

Uninterruptible power supplies (UPS) were provided to all scram circuits in 1982 and to the Safety Computers (including ABS logic) in 1983. The UPS will maintain the computers and scram circuits online a minimum of 5 minutes following loss of all offsite power.

Fuel Handling

The chuck fingers on the machines were lengthened in 1981 to assure the assembly would be held in the mast if the chuck released the assembly and it rested on the rinse water collection pan beneath it.

A computer system was added in 1982 to control the order of charging of the assemblies, further eliminating manual input and increasing protection against criticality from misload errors.

Seismic

A weld examination program was completed in 1983 to establish the quality of carbon steel piping welds in the cooling water and ECS systems. Samples from over 100 welds in the L-Area system piping were destructively examined and quantitatively characterized as to quality. Also, a large number of additional welds were radiographed and inspected by an outside consultant. The analyses concluded that the quality of the welds in these systems meets the structural requirements of a design basis earthquake.

Studies in Progress

Confinement

The program toward continuous study of improved confinement of radioactive releases includes efforts in several areas:

- Experiments are in progress to determine the effectiveness and feasibility of using solid adsorbents (mordenites, zeolites) for adsorption of noble gases. The program to assess technical feasibility and economic practicality continues with high priority.
- Fuel melt experiments with irradiated SRP fuel samples are planned. The goal is better characterization of the source term to be expected from a fuel melt accident; analyses of the Three Mile Island damaged core material suggest the current assumptions may be vastly overconservative. An improved source term may greatly reduce offsite dose expectations.

- Studies are continuing to evaluate several confinement/containment system design alternatives. Cost estimates and measures of effectiveness are being developed for tall stacks, internal building containment, a containment dome, and a system for temporary holdup of airborne contamination to allow for decay of short-lived products before filtration/release.

ECS

The primary design basis accidents for the ECS are the very large cooling water or process water leaks or the loss of D₂O circulation. Concepts are now being developed for coping with smaller leaks which may propagate to a need for ECS actuation. Ideas include increased D₂O makeup capacity or collection and recirculation of the D₂O leakage. Recirculation of the leakage and/or ECS water back to the reactor inlet lines would reduce the amount of contaminated water which exits the building and provide a non-exhaustive supply of cooling water.

A second booster pump has been proposed and basic data written to provide an improved source of ECS water.

Fuel Handling

Two safety improvements packages for the charge and discharge machines are scheduled for installation in 1983-1985. The projects will provide:

- Expanded computer control of C&D operations
- A directable spray nozzle for cooling a dropped assembly
- Closed circuit television camera monitoring to enhance visual observation of C&D operations
- Improved supply of power for the machines with better handling facilities for the moving cable system
- Assembly temperature monitoring capability
- Better personnel access to the machines and controls to facilitate routine or emergency maintenance

Seismic

Studies to date have provided seismic analyses of and necessary bracing for important systems and building structures. A continuing program is in progress to:

- Complete assessments of the overall integrity of the CW, PW, and ECS piping with respect to weld and pipe failure characteristics
- Complete a stress analysis of the piping systems to define maximum points of stress and magnitudes during a design basis earthquake

- Define the spectrum of piping leaks and consequences thereof
- Establish acceptability bands for seismic safety margins
- Estimate seismic risk
- Retrofit bracing, etc., if necessary to bring risks within acceptable range

Three Mile Island Followup

The March 28, 1979, accident at Three Mile Island (TMI) had significant implications for nuclear power generating facilities. Because the SRP reactors are operated at essentially atmospheric pressures, and because of the absence of the auxiliary systems for electric power generation, a similar incident is not possible at Savannah River. However, there are many lessons to be learned in the areas of operator response, technical personnel availability, instrumentation adequacy, and accident propagation. To take advantage of any possible lessons, a committee was formed on April 4, 1979, to assess implications of the TMI incident for SRP operations. Recommendations were formulated for any changes in operation or improvement programs indicated by lessons apparent from the TMI experience. Three areas in which changes were indicated are discussed below along with the status of each.

Technical

The TMI implications for the technical arena were assessed by SRL and SRP personnel and led to acceleration of major projects already being developed in the areas of alarm diagnosis and system availability monitoring. Other changes of less magnitude are also discussed below.

Diagnosis of Multiple Alarms (DMA)

The Diagnosis of Multiple Alarms (DMA) system is a pioneering application of computer-based diagnosis of malfunctions in operation. This system, developed at SRL-SRP, is designed to aid operators in managing abnormal reactor conditions by automatically analyzing patterns of alarms and sensor inputs. During 1982, the installation of the DMA system was completed in all SRP reactors. Work on this system is continuing with the development of closed-circuit television systems to make possible visual recognition and assessment of leaks in reactor cooling systems. Four cameras are currently installed for evaluation in the P-Reactor process areas.

The heart of the DMA system is the alarm logic tree. These are similar to fault-trees developed in process hazard analysis work. Simple alarm trees define the general problem. More complex alarm trees pinpoint the location within the plant. There are currently 45 logic trees to recognize conditions that could lead to the loss-of-coolant or loss-of-circulation accidents. Any diagnosis is displayed on a large television in the control room. The message defines the root cause of the alarms and identifies the correct emergency procedure to be used.

Essential Equipment Monitor (EEM)

Also beginning in 1982, the Essential Equipment Monitor (EEM) was installed in all areas. The EEM will continuously monitor ECS valves and other essential equipment and give an immediate indication of a majority of electrical failures. A programmable controller in the central control room will scan fault sensing circuits and initiate an alarm for such failures as an open or bad connection, loss of ground, short to ground, or loss of voltage. EEM monitoring will significantly decrease critical equipment unavailability from these common electrical problems and help ensure compliance with operating requirements. The system is in a test mode in all three operating reactors and will be made operational when checkout and procedures for response to alarms are complete.

Postaccident Monitoring

In response to review of postaccident monitoring adequacy, a project was authorized to provide radiation monitoring equipment with increased monitoring range and life expectancy. Such monitoring upgrade is being provided for both airborne and liquid effluent streams under accident conditions. Assessment of confinement system seals indicates sufficient radiation tolerance for system function for extended accident conditions.

Postaccident monitoring and control improvements also include:

- The reactor remote control facilities are scheduled for computerization and upgrade. Control of an evacuated reactor area will be possible from the existing remote facility as well as from another reactor control room.
- Evacuation signals for reactor buildings are being improved by upgrade of area communications systems. Work is complete in 2 of the 3 operating areas.

Other

Other items included in the technical/design area are:

- Concepts have been documented and are currently being evaluated for improving the ECS design to better cope with small leaks which may propagate to accident conditions. A small flow rate light water addition system or increased D₂O makeup are being considered.
- A preliminary report on mechanisms to retain noble gases from a fuel melt release has been issued. The alternatives are being evaluated in terms of cost and benefit.
- A probabilistic risk assessment (PRA) is being conducted for the reactor safety systems to extend earlier analyses of risks versus all postulated accidents. An outside contractor has begun work on a systematic analysis of the electric power system and other systems analyses will follow.

Many TMI-related technical analyses were completed with no resultant action deemed necessary. Studies continue on various other subjects and status is formally reported to DOE-SR periodically.

Training

Assessment of the Reactor Department training program revealed inadequate documentation of the training methods, material covered, and program format. A detailed description was subsequently written entitled "Reactors Personnel Selection, Qualification and Training Manual." Many parts of the training program have been strengthened as a result of the assessment and are described in the Training Manual.

- Position titles, job descriptions, and responsibilities are well defined and understood.
- Level of knowledge requirements were established and detailed for all certified personnel training and retraining programs.
- Specific tasks and training requirements for certified operators and supervisors are being delineated through POSITION TASK ANALYSES performed by an independent contractor. The Training Manual will include qualification and training requirements identified by these analyses.
- Realistic accident scenarios were developed and documented in training material.
- Procedure writer qualifications were established and included in the manual.

In addition to the better definition and documentation of the training program several other changes are being effected:

- A fifth operating shift was effectively established by providing additional operations staffing to allow certified personnel to be relieved for continued training and recertification.
- The training period was lengthened from 9 months to 1 year to facilitate additional classroom training and control room experience.
- An independent certification board was established to review each operator or supervisor candidate. The board of SRL and SRP technical personnel will review the program and oral and written examination performance to accept or reject the candidate.

Simulator

The most significant addition to the Reactor Department training program will be the building of a reactor control room simulator. An experienced outside contractor, Singer-Link, is developing the computer models necessary to provide real-time instrument response to a variety of postulated accidents. A full-size replica of the K-Reactor central control room will be provided. The control room will look, respond, and sound like the K-Reactor control room.

All controls, instruments, and alarms that could be involved in significant training exercises will be interactive with the computer complex. The few controls, instruments, and alarms that are not interactive with the computer complex will appear normal to the operators.

Most of the instruments in the control room will be simulated in a manner to appear real to the operator, but internally will be designed or modified to be compatible with a standard set of drive signals developed for the simulator computer complex. The control and safety computers will be stimulated (receive the same signals as they do in a real control room) so that future control and safety computer software changes can be implemented in the simulator more easily.

The simulator is expected to be operational by 1985.

Programmatic

Procedures Upgrade

Numerous deficiencies identified in procedure format and standardization resulted in increasing the procedure writer staff three-fold to expedite improvements. Items being addressed include:

- All operating, emergency, and master control procedures were reviewed for relationship to or implications from the TMI experience.
- All procedures are being converted to a standard format to facilitate usage, revisions, and training. This effort is more than 80% complete.
- Bases sheets for all emergency procedures are being developed or updated to provide reference documentation of basic concepts and logic.

Quality Assurance

The Savannah River Quality Assurance (QA) program has been formally documented and implementation continues at a rapid pace. Reactor programs have been affected in several major areas:

- Training in basic QA principles and programs were incorporated into all reactor supervisory training and retraining courses.
- A formal program was implemented to incorporate QA requirements into operating procedures. The system consists of a QA assessment and development of detailed Action Plans based on the results. The Action Plans are implemented through normal procedures. Assessment of existing reactor facilities is complete. Resultant procedure upgrade is about 80% complete.
- Surveillance of reactor operating procedures by an independent QA group was increased. Fifteen audits were conducted by the SRP QA Department (wholly independent of operational responsibility) in 1982. Audits included effectivity of compliance to established written procedures as well as determination of whether findings were generic or isolated.

Other

Other programmatic changes effected since the (TMI) review began include:

- Reactor Incident report reviews were incorporated as a mandatory part of the continued training for certified reactor supervisors and operators. Lessons learned from each incident are reviewed with maintenance, operations, and engineering personnel as appropriate.
- Shift checklists were converted to reactor procedures and formalized procedures for shift turnover were provided.
- A document is being prepared to provide plantwide standardization of tool calibration requirements. Tools will be calibrated proportional to need as determined by frequency, precision, and tolerance demands.
- The commitment of Du Pont to the ALARA (As Low As Reasonably Achievable) radiation dose reduction program is being documented. The document describes drills used as part of the radiological controls and the program for conducting internal audits.
- The Maintenance Information and Control (MIAC) system was upgraded to ensure better control of equipment availability and to improve the ability to detect equipment performance trends.

APPENDIX K

SCOPING COMMENTS

Pursuant to the National Environmental Policy Act of 1969 and the Energy and Water Appropriations Act, 1984, Public Law 98-50, the Department of Energy (DOE) initiated the preparation of an environmental impact statement (EIS) on the proposed restart of L-Reactor on an expedited schedule. A Notice of Intent (NOI) was published in the Federal Register on July 19, 1983. The NOI announced (1) a 22-day scoping period, inviting comments on a proposed scope for the EIS, and (2) four scoping meetings to be held in two cities in South Carolina and two cities in Georgia to receive oral comments.

By August 14, 1983 (the scoping period officially closed on August 10, 1983), 27 individuals had offered oral comments at the scoping meetings, several on behalf of organizations. Written comments were received from 27 individuals and organizations, 12 of which were written copies of oral testimony. DOE has considered late comments to the extent practicable.

More than 270 separate comments and recommendations were expressed in the scoping comments. This appendix identifies and discusses the areas of interest expressed by the commentors; annotated copies of transcripts and letters respond to each point. In addition to environmental issues, a number of comments deal with procedural and administrative concerns. This appendix also includes transcripts of the statements and copies of the written letters.

Table K-1 lists scoping topics raised in the comments and recommendations, and presents a cross-index of the sections in the EIS that address these topics.

Tables K-2 and K-3 list the speakers who provided statements and their oral statements, respectively. Tables K-4 and K-5 list authors of scoping letters and their letters, respectively. Tables K-3 and K-5 are also annotated with references to EIS sections where a subject is addressed, or with statements that present DOE's response to a comment or recommendation.

Copies of the oral statements and scoping letters are available for public inspection at the DOE Public Reading Room, 211 York Street, NE, Aiken, South Carolina. Copies are also available for public inspection at the following locations:

Freedom of Information Reading
Room
Room 1E-190
U.S. Department of Energy
Forrestal Building
1000 Independence Ave, SW
Washington, DC 20585

U.S. Department of Energy
211 York Street, NW
Federal Building,
Aiken, South Carolina 29801

Augusta Regional Library
902 Greene Street
Augusta, Georgia 30901
(404) 724-1871

Warren C. Gibbs Memorial Library
326 North Bel Air Road
Evans, Georgia 30809
(404) 863-1946

Burke County Library
Fourth Street
Waynesboro, Georgia 30830
(404) 554-3277

Statesboro Regional Library
124 South Main Street
Statesboro, Georgia 30458
(912) 764-7573

Atlanta Public Library
1 Margaret Mitchell, NW
Atlanta, Georgia 30303
(404) 688-4636

Richland County Public Library
1400 Sumter Street
Columbia, South Carolina 29201
(803) 779-9084

South Carolina State Library
1500 Senate Street
Columbia, South Carolina 29201
(803) 758-3181

Aiken-Bamberg-Barnwell-Edgefield
Regional Library
1307 Georgia Avenue
North Augusta, South Carolina 29841
(803) 648-8961

Allendale-Hampton-Jasper
Regional Library
War Memorial Building
Court House Square
Allendale, South Carolina 29810
(803) 584-3513

Charleston County Library
404 King Street
Charleston, South Carolina 29403
(803) 723-1645

Chatham County Public Library
2002 Bull Street
Savannah, Georgia 31499
(921) 234-5127

Screven-Jenkins Regional Library
302 East Ogeechee Street
Sylvania, Georgia 30467
(912) 564-7526

Washington Memorial Library
1180 Washington Avenue
Macon, Georgia 30467
(912) 744-0800

Aiken County Public Library
435 Newberry Street
Aiken, South Carolina 29801
(803) 649-2352

Orangeburg County Free Library
510 Lories NE
P.O. Box 1367
Orangeburg, South Carolina 29115
(803) 531-4636

Beaufort County Library
710 Craven Street
Beaufort, South Carolina 29304
(803) 524-0762

Spartanburg County Library
333 South Pine Street
Spartanburg, South Carolina 29304
(803) 596-3505

Greenville County Library
300 College Street
Greenville, South Carolina 29601
(803) 242-5000

Table K-1. Scoping topics and EIS sections

Scoping topic	EIS section
Accident analysis	4.2.1, 4.3.2.3, 4.4.1, 4.4.5, App. G
Alternatives--cooling	4.4.2
Alternatives--production	Chapter 2
Atmospheric effects	4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, App. B
Cumulative radiological effects	5.1.2, 5.2.6, 3.7.1
Emergency planning	4.2.1.3, App. G, App. H
Endangered species	3.6.1.4, 3.6.2.3, 4.1.1.4, 7.3, App. C
Fisheries	3.6.2, 4.1.1.2, 4.4.2, 5.2.4.2, 5.2.5, App. C
Ground-water contamination	4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, App. F
Ground-water usage	4.1.1.3, 5.2.3
Health effects	3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, 6.1.4, App. B, App. G
Mitigation measures	4.4
Monitoring	Chapter 6
Need	1.1
NEPA procedures	Foreword
Radioactive waste	4.1.2.8, 4.3, 4.6, 5.1.2.8
Radiocesium remobilization	3.7.2, 4.1.2.4, App. B, App. D
Radiological effects	3.7.1, 4.2.1, 5.1.2, 5.2.6, App. B, App. D, App. G
Regulatory requirements	Chapter 7
Safety alternatives	4.4.1, 4.4.5
Seepage basins	4.1.2.2, 4.4.3.2, 5.1.1.2, 5.1.2.1
Socioeconomic effects	4.1.1.1, 4.2.1.5, 5.1.1.1, 5.2.1
SRP and regional effects	3.7.1, 5.2
Surface-water use	4.1.1.2, 5.1.1.4, 5.2.2, App. D
Thermal effects	4.1.1.4, 4.4.2, 4.4.3.4, 5.2.4, 5.2.5.1
Tritium	4.1.2.1, 4.1.2.2, 4.2.1.4, 4.3.2.3, 4.4.3.2, 4.4.3.5, 4.4.5, 5.1.2.1, 5.1.2.2, 5.2.6
Wetland impacts	4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, App. C, App. I
Wildlife	3.6, 4.1.1.4, 4.4.2, App. C, App. I

Table K-2. Scoping meeting speakers

Witness	Hearing appearance	Representing	Page
Barnes, Travis	8/1 am	State Representative, Georgia 90th District	K-5
Benedict, Lawrence	8/5 am	The Georgia Conservancy, Coastal Citizens for a Clean Environment	K-55
Brown, Virginia	8/5 am	League of Women Voters of Savannah-Chatham	K-62
Denton, John	8/2 am	Self	K-33
Dillon, Zaida	8/4 am	Self	K-50
DuTeau, Gary	8/1 pm	Self	K-13
Dykes, Virginia	8/1 am	Self	K-28
Gordon, Judith	8/1 pm	Sierra Club, South Carolina and Georgia Chapters	K-6
Graber, Susan	8/4 pm	Self	K-49
Harrington, Ann	8/4 pm	Self	K-51
Hart, Frances	8/2 am	Energy Research Foundation	K-16
Heath, Melissa	8/5 am	Self	K-64
Jones, Beatrice	8/2 pm	Self	K-35
Kelly, Mary	8/2 am	League of Women Voters of South Carolina	K-20
LeMay, Geraldine	8/5 am	League of Women Voters of Georgia	K-52
Lowe, Michael	8/2 am	Palmetto Alliance, Inc.	K-25
Maclean, John	8/5 pm	Several individuals	K-67
Matthews, Ken	8/5 am	Savannah Chamber of Commerce	K-59
McDaniels, William	8/2 am	Self	K-26
Price, Sister Helena	8/4 pm	Self	K-48
Reed, Joel	8/5 am	Self	K-61
Seymour, Mary Lou	8/2 pm	Self	K-42
Stallings, James	8/2 am	Self	K-22
Stoney, S. David	8/1 pm	Self	K-9
Tilson, Elwin	8/5 pm	Self	K-65
Tsagos, Zoe	8/4 am	League of Women Voters of northern Beaufort County	K-44
Wise, Barbara	8/2 pm	Self	K-39

Table K-3. Scoping statements and EIS sections or DOE's responses

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF THE HONORABLE TRAVIS BARNES STATE REPRESENTATIVE, 90TH DISTRICT, GEORGIA			
	I think maybe that some of y'all have gone to a lot of trouble. You may feel like people who have organized a banquet and have all the places set and nobody comes, but I think it is important that you all are taking this extra precaution before the reactivation of this L-Reactor.		
	Really, I have no criticisms. In fact, I want to commend the Department of Energy. I have been receiving almost on a bi-weekly basis a lot of information about the L-Reactor and what possibly is its impact.		
	This is written for engineers, and my training was philosophy and theology, so I have had a little bit of a tough time with it. Yet I think the fact you all are having hearings and taking a second look at any effect the L-Reactor will have in its reactivation on this area is good.		
A1	As you may well all know, there are over 350,000 people in the metropolitan area of Augusta and we do have a concern about any environmental impact it might have on our area, both as far as individuals biologically, perhaps, the chance of emissions, and particularly our neighbors to the south of us who are concerned about groundwater affecting their drinking water, perhaps, of the many thousands of people. So we are glad that the government is taking a second look and making sure that the public interest is fully protected. And really my only question I would have to you would be: Have all of these precautions been made and are we double-checking, double-checking the possible effect of any emissions or any effect on the atmospheric conditions as well as the groundwater?	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, 6.1.4, Appendix B, Appendix G
A2		Groundwater use	Sections 4.1.1.3, 5.2.3
A3		Atmospheric effects	Sections 4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, Appendix B
A4		Groundwater use	Sections 4.1.1.3, 5.2.3

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF JUDITH E. GORDON REPRESENTING SOUTH CAROLINA AND GEORGIA SIERRA CLUB			
B1	I am Judith E. Gordon representing the South Carolina and Georgia chapters of the Sierra Club with a membership of about 5,000 in the two-state area. I thank you for this opportunity to express the environmental concerns of the Sierra Club with respect to the proposed restart of the L-Reactor at the Savannah River Plant.		
	In its public notice, DOE has identified several environmental issues to be addressed. However, I did not see listed one of the most important issues; that is, the destruction of wetlands habitat.	Wetland impacts	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
	The percentage of SRP wetlands that will be affected by L-Reactor restart varies with how the calculations are made and with how wetlands are defined. Nonetheless, by DOE's own calculations, only 36 percent of Savannah River Plant wetlands have not been affected by thermal discharges. Since loss of wetlands has become a priority--of priority in environmental concerns, both at federal and state levels, I request that in assessing wetland losses, DOE take into account: 1. The literature from the federal agencies concerned, for example, studies done by the Fish & Wildlife Service of the Department of the Interior. 2. Studies done by South Carolina and Georgia state agencies on the importance of wetlands and their rate of loss. There are other concerns I would like to emphasize using the categories suggested by the Department of Energy.		
B2	No. 1. Socioeconomics: Since an Environmental Impact Statement typically discusses the jobs provided by the facility, I believe the other side of the economic coin should also be discussed in the EIS; specifically, what mitigating measures will the Department of Energy implement to lessen the job crisis	Socioeconomics	Section 4.6

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	that will ensue when the aging reactors at the Savannah River Plant are shut down, including eventually the L-Reactor itself.		
B3	2. Endangered Species: The EIS should certainly incorporate the results of ongoing research being done at the Savannah River lab on river ecology and the Shortnose Sturgeon. It should also include a Woodstork study currently under way at the Savannah River Ecology Lab.	Endangered species	Sections 3.6.1.4, 3.6.2.3, 4.1.1.4, Appendix C
B4	3. Fisheries: The EIS should estimate the cumulative effects on fish passage from all thermal plumes in the river area, not just that of L-Reactor.	Fisheries	Sections 5.2.4.2, 5.2.5.1
B5	4. Radiological Effects and Safety: The EIS should address the estimated contamination and hazards resulting from a worst possible accident at the L-Reactor; nothing less than that.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
B6	No. 5. Groundwater Contamination: In view of the reported contamination of the Tuscaloosa Aquifer, the EIS should explain what errors were made in previous studies that assured the public that there was no reason to be concerned about pollution of aquifers. This should be contrasted with explanations of how the various wastes from the L-Reactor restart would be handled to prevent further contamination. Finally, I would like to make two general comments that I feel DOE should consider in the preparation of this EIS. Number one, as a government agency, the Department of Energy should set an example such that everyone would be aware of the concern of the federal government for environmental quality.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F. Mitigation of groundwater contamination at SRP will be the subject of a separate NEPA review.
B7	In particular, the federal government surely would not be in the position of exempting itself from standards that it expects private industry to meet, and I make this point in particular reference to the water standards set by the State of South Carolina and the attempts to have these put aside so that the reactors at SRP can be allowed to discharge hot water into the streams on site.	Regulatory requirements	Chapter 7 The DOE is responsible for assuring health and safety for its own facilities. In addition, the DOE will be in compliance with all applicable Federal and State regulations.
B8	Number two, if the Department of Energy expects to establish credibility for its statements and actions, then it is time that it quit monitoring itself and establish a fund through	Monitoring	Chapter 6 In addition to the SRP monitoring programs, both the States of South

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	which independent agencies would monitor both radioactive and nonradioactive discharges from the facilities contracted by DOE. It is doubtless too late to begin this process for the EIS in question, but it should certainly be possible for future endeavors.		Carolina and Georgia have implemented State-wide environmental monitoring programs. Also, the State of South Carolina monitors SRP activities for compliance with State regulations and administration of environmental laws.
89	There is one more thing I would like to add which is not in the statement, and I would like to say that I think it would certainly be an advantage to everyone if the comments--the comment period on the EIS could be extended to 45 days rather than 30 days. I think it is going to require that amount of time to effectively judge the EIS.	Procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF DR. DAVID STONEY, JR.			
	My name is David Stoney, Jr., and I am employed as a researcher and teacher at a local medical college. I have a Ph.D. in physiology. I am here tonight to express my concerns as a private citizen about some of the aspects about the restart of the L-Reactor.		
	I appreciate the opportunity to be here. I am glad we are finally going about this thing right.		
	As a remark at the beginning of things, I would like to say that I felt that some information was left out of the background information that Mr. Sires presented regarding this L-Reactor suit and its consequences.		
	For example, the suggestion by Mr. Robert Morgan in the spring of 1981 to a Subcommittee of the Senate, I believe, that an exemption from the National Environmental Policy Act requirements would be beneficial. Some items like that, I think, fill out the background on this dispute.		
	I would like to address two or three issues that I think are important and that I am not certain will be covered with sufficient detail and the in-depth analysis that is deserved in the Environmental Impact Statement.		
C1	First of all, the radiologic effects of the routine and accidental releases of radioactivity from the Savannah River Plant. I note that you plan to give us finally the cumulative dose commitments from routine operations of the L-Reactor.	Cumulative radiological effects	Sections 5.1.2, 5.2.6
	I think those cumulative dose commitments from the L-Reactor should be combined with cumulative dose commitments from all the other radioactivity-producing activities and facilities at the Savannah River Plant.		
	These, I believe, should be explicitly presented and the health effects from those dose commitments should also be explicitly set forth in the Environmental Impact Statement.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C2	The estimates of the health effects should reflect, first, those due to the operation of the L-Reactor in the context of the entire Savannah River Plant operations, as well as in the context of neighboring nuclear facilities, such as the Vogtle Plant, which will be coming on line presumably in the near future. So we should see not only the incremental effects from the L-Reactor but how those effects add to what is already being produced from the Savannah River Plant.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B
C3	In addition to estimating the health effects from the total radioactivity dose commitment from Savannah River Plant activities, I think those commitments, those health effects should be taken also in the context of the increased radioactive background, if you will, in the Northern Hemisphere by the activity of all other nuclear facilities, mostly commercial nuclear facilities. I have read, for example, in the 1982 edition of the Encyclopedia Britannica that they anticipate by the year 2000 a doubling of background radiation due mostly to commercial nuclear facilities.	Health effects	Sections 3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B
C4	Let's take a look at the total health effects, not only from the L-Reactor but also from all the other Savannah River Plant activities, look at that dose on top of the dose we are getting from the rest of the world, if you will. I expect to see in the Environmental Impact Statement at least three sets of data about health effects. One, those incremental effects associated with the restart of L-Reactor; two, those effects associated with the entire Savannah River Plant and neighboring nuclear facilities activities, including those from the L-Reactor; and finally, those associated with global Northern Hemispheric nuclear activities, including our own regional contributions thereto. Only then, when we look at all of that data, can the citizens of this area really know what the health effects are.	Health effects	Section 3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C5	I second Dr. Gordon's call, and I point out to Mr. Cumbee and to this hearing that several other people--for example, Dr. Cochran and Dr. Scheer of the Natural Resources Defense Council--have called for a release of information about the consequences of a full core meltdown accident at the L-Reactor. According to your published statement, apparently you intend to do that. You indicate consideration of postulated beyond design basis accidents and probabilities. Mr. Sires didn't mention that, I don't believe, in his verbal address. Am I to understand that you do intend to consider a full core meltdown accident, Mr. Sires?	Accident analysis	Section 4.2.1, Appendix G
C6 C7	I believe that the Environmental Impact Statement should fully analyze the health and environmental effects, indeed the social and the economic effects, of accidents up to a full core meltdown.	Health effects Socioeconomic effects	Section 4.2.1.5, Appendix G Appendix G
C8	This is what would be required for any commercial nuclear reactor. It is what the people of this area want to know; what is the bottom rung for producing plutonium for bombs here. We deserve to know it; we want to know it.	Regulatory	See Comment B7
C9	In this regard, there is one area that I have spoken to before that is not considered in your outline of scoping areas. This is the question of what happens in the case of radiologic emergency at the Savannah River Plant. We need to know, and I think the Environmental Impact Statement should spell out the mechanisms for dealing with us, the surrounding populations in the event of a major radiologic accident at Savannah River Plant. There are tens of millions of curies of radioactivity in the inventory of L-Reactor, or at least there will be after its startup. I want to know what to do with my grandchildren if there is a full core meltdown at the L-Reactor with the wind blowing 15 knots right to Augusta. What are at least the control, the communication procedures in the event of such an accident? We want to know.	Emergency planning	Section 4.2.1.3, Appendix H

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
C10	Mr. Cumbee, thank you for the opportunity to speak to these issues. I look forward to reviewing the draft EIS document. I request specifically that the period for review of the draft EIS be the full 45-day period as suggested by law. I think the population deserves that chance to look at what will be, for the first time, I think, a fairly direct consideration of Savannah River Plant activities.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF GARY DUTEAU			
	I am a private citizen here in Augusta. I have been in business here, and I am now farming a little bit in South Carolina. I'm still associated in business here in Augusta and a resident.		
	Now, I would like to preface my remarks by saying, of course, as you know, there are millions of people like myself who object to the procedures which the government has sometimes used in order to determine what is safe for the public. Now, I'm a college-educated man, and I am very familiar with the issues. I have read extensively on it. I have followed the nuclear development and I am familiar with the weapons issue.		
D1	I am opposed to an unending manufacture of nuclear weapons; and as I say, these issues--these attitudes that I have are reflected in many people of the population, not all of whom may be here. I do not know exactly how well you encouraged people to come. I found out about this through a friend.	Need	Section 1.1 Consideration of the rationale in establishing the need is beyond the scope of the EIS.
	I think that the chemical industry which is involved here, DuPont being a leading member of that group, and I think the American Government has very frequently, when something like this--when it comes to nuclear energy, when it comes to chemical waste, has gone off half cocked, assumed that anything they decided would be in the public interest because they have that trust.		
	I think we could probably list thousands of examples which originally begin with ignorance on the part of the government because they feel like they know enough to decide an issue. Now, we are talking about an Environmental Impact Statement, I realize, and that is an attempt to educate yourself as the government, as the company who is going to be doing this work, with potential dangers to the public and to the environment.		
	Now, Love Canal, Agent Orange, 2,000, I think it is, chemical waste dumps which are hazardous around this country where companies have walked off and left their garbage laying around; very deadly.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
D2	One thing I object to specifically, and I think this is indicative of the problem here, and the scope of it is through ignorance, originally feeling it was going to be easy to take care of, we wound up with, I think, around 27 or over 20 million gallons of radioactive waste. We have had many leaks into the environment. That's common knowledge now. Have many safety problems. The chemical industry in general has a tremendous number. Right now thousands of plants are releasing their effluents into streams illegally and legally.	Radioactive waste	Sections 4.1.2.8, 4.3, 4.6, 5.1.2.8
D3	To be direct, then, I think a full and comprehensive study should be undertaken, particularly evacuation in the case of a core meltdown or other significant accident.	Emergency planning	Section 4.2.1.3, Appendix H
D4	I think they should study the problems within the company of foreseeing and preventing problems which they have not demonstrated their ability to do, at least real well. They have projected ahead and discovered many things that could be problems, but by and large, we have had many releases, unsafe releases of gas, unscheduled, and I think that in the study, we should examine why those things happen; human error, I guess.	Accident analysis	Section 4.2.1.2
D5	Also, an evacuation plan and the effects of the releases; cancer, specifically.	Health effects	Section 4.2.1.5, Appendix G
D6	How well the aquifer can be protected, I think, should be included in the study. I personally do not think that it's necessary to do it but, of course, if the government--if the members in the government decide they will impose this, then I think that they owe it to the public to attempt to protect them from that which they have not been able to do so far due to their own mistakes, lack of knowledge especially in foreseeing what could be problems, waiting until they have problems rather than looking ahead with a study. Now, from what I have heard, there is some question as to whether or not there will even be an Environmental Impact Statement that is very broad in scope. Originally they felt it was unnecessary, and now we are here to find out if the public objects to such a cursory examination.	Groundwater contamination	Sections 4.1.1.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F. See Comment B6.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
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I would like to see it as thorough as possible.

That's all I have to say.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF MRS. FRANCES CLOSE HART			
I am Frances Hart, and I'm making these comments on behalf of the Energy Research Foundation of Columbia, South Carolina. My comments are largely based on written comments which will be submitted for the record by the National Resources Defense Council on behalf of plaintiff groups in the EIS lawsuit. We assume that the Department of Energy, in accordance with the National Environmental Policy Act, will address clearly and fully the environmental impacts of the L-Reactor, particularly those which have been repeatedly identified as matters of concern in litigation, Congressional and administrative hearings, and statements, letters and other comments of federal and state officials and technical personnel, and the public. We assume that DOE will make a concerted effort to fill the existing gaps in knowledge regarding the impacts of the L-Reactor which have been previously pointed out.			
E1	We also anticipate that DOE will give objective consideration to all reasonable alternatives keeping in mind the following statement taken from a Council on Environmental Quality Memorandum to federal agencies concerning NEPA regulations: "The phrase 'range of alternatives'...includes all reasonable alternatives, which must be rigorously explored and objectively evaluated.... In determining the scope of alternatives to be considered the emphasis is on what is 'reasonable' rather than on whether the proponent or applicant likes or is capable of carrying out a particular alternative. Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant." Specific comments on the proposed scope of the EIS include the following:	Alternatives	Chapter 2, Section 4.4
E2	The draft EIS should contain a justification for the proposed startup of the L-Reactor, particularly in regard to the timing,	Need	Section 1.1
E2	which has relevance for the operational alternatives which would eliminate or reduce the environmental harm and hazards	Alternatives	Section 4.4

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	associated with operation as proposed in the Environmental Assessment.		
E3	There are substantial questions as to the immediacy of the need for the plutonium to be produced by the L-Reactor, whose startup was initially called for in 1980. For example, the number of warheads for the MX missiles now scheduled to be deployed has been reduced from approximately 2,000 to 1,000. It is estimated that the L-Reactor will produce each year enough plutonium for some 75 to 100 nuclear warheads. Thus, the reduction in the MX program alone suggests that operation of the L-Reactor may be delayed without risk to our nation's security in order to implement mitigation measures prior to startup. DOE representatives have repeatedly testified before congressional committees that the L-Reactor is needed to meet a possible shortfall in nuclear weapon materials in the early 1990's. As a result of other production initiatives, DOE is now already ahead of its targets to boost the production of these materials. And recently the House Armed Services Committee found that "there is no basis to assume that large numbers of nuclear weapons will be produced in the years beyond 1990."	Need	Section 1.1 See Comment D1
E4	The draft EIS should consider as a reasonable alternative a delay in the operation of the L-Reactor for an extended period to allow the implementation of mitigation alternatives combined with production alternatives if necessary.	Alternatives	Sections 2.3, 4.4
E5	In order to provide a rational basis for this decision, the draft EIS must provide and disclose to the public, to the fullest extent possible, data in response to the following: 1. Identify each material production alternative through 1995; 2. Identify by year the plutonium-equivalent production capability of each alternative; 3. Identify for each year the plutonium-equivalent inventory, stockpile, and future requirements;	Need	Section 1.1

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	4. Indicate precisely which, if any, weapons systems and requirements would have to be delayed if the L-Reactor operation was postponed one, two, three, or four years; and 5. Indicate whether and how a delay in L-Reactor operation of one or two years would affect the production of warheads already scheduled to 1988, or plutonium contingency needs in the "out years."		
E6	The draft EIS should fully disclose both the capital and operational costs of each cooling water alternative, with complete documentation of such costs and scheduling to permit meaningful outside review.	Alternative cooling	Section 4.4.2 Selection of thermal mitigation measures for all SRP thermal discharges will be the subject of a separate NEPA review.
E7	The draft EIS should consider the costs as well as the benefits associated with employment and related economic impacts of L-Reactor operations. Continuing or increased reliance on the Savannah River Plant could present indirect costs to the area, such as the drain on skilled technical personnel who are thus not available to the private sector. The area's dependence on this one source of employment and economic stimulation could present problems should national developments bring about a decrease in SRP's operating budget.	Socioeconomic effects	Sections 4.1.1.1, 5.1.1.1, 5.2.1
E8	Socioeconomic benefits from implementation of various mitigation alternatives must be weighed against supposed costs of delay.	Alternatives	Section 4.4.1.6
E9	An accidental release could have serious implications for economic development in the region, particularly those areas downstream and downwind of SRP, and socioeconomic effects in the larger Savannah River Basin of such releases, and of water contamination, should be assessed.	Socioeconomics	Section 4.2.1.5
E10	The draft EIS should describe the increase in the withdrawal of Savannah River water for cooling purposes and any indications of existing and potential conflicts in the use of this resource, such as the proposed hydroelectric facility on the Augusta Canal. Concerns about adequacy of freshwater supplies in coastal areas and suggested increased use of the Savannah River for drinking water must be taken into account. And adequacy of river flow in times of drought, a concern expressed by the Corps of Engineers, must be addressed.	Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
E11	The dose commitments from the routine operations of the L-Reactor, including radiocesium transport, and from L-Reactor accidental releases should be measured against the same standards applied to commercial nuclear reactors and using the same methodology. The draft EIS should clearly identify where those standards, namely 10 CFR Parts 50 and 100, would be exceeded by the L-Reactor and by SRP as a multi-reactor site.	Regulatory requirements	Sections 4.1.2, 4.2, 5.1.2, 5.2.6, Appendix B, Appendix G
E12	Impacts from cesium transport should be evaluated particularly with regard to the flooding of Creek Swamp Plantation and possible concentrations in fish such as the largemouth bass, which can have a concentration factor as high as 10,000. The impacts must be considered in light of consumption of fish downstream of Creek Swamp Plantation.	Radiocesium	Sections 3.7.2, 4.1.2.4, 4.2.2.5, Appendix B, Appendix D
E13	The draft EIS should fully analyze the impacts of all possible reactor accident sequences, including so-called Class 9 accidents, as is required of all commercial reactors and using the same methodology. Environmental, social, and economic effects of accidents up to a full-core meltdown should be considered. Costs and impacts from construction of containment domes for SRP's reactors should be included in the draft.	Accident analysis	Section 4.2.1.5, Appendix G
E14		Safety alternatives	Section 4.4.1.6, Appendix G
E15	The draft should include a liquid pathways assessment to analyze the effects of L-Reactor accidental releases on ground and surface waters, as well as drinking water from the Savannah River.	Accident analysis	Sections 4.2.1, 4.3.2.3, Appendix G
E16	Finally, the draft EIS should contain a clear explanation of the sources and consequences of the existing groundwater contamination at SRP in all areas which will in any way be affected by L-Reactor startup, including the M-Area. It should provide full documentation as to the possible movement of contaminants to deep aquifers. The discussion in the draft EIS should provide a basis for selection of an alternative to the present outdated reliance on seepage basins. Plans for compliance with federal and state environmental regulations, such as the Clean Water Act and the Resource Conservation and Recovery Act, should be discussed.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F
E17		Seepage basin alternative	Section 4.4.3
E18		Regulatory requirements	Chapter 7

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF DR. MARY KELLY			
F1	I am Dr. Mary I. Kelly, First Vice-President and Natural Resources Coordinator for the League of Women Voters of South Carolina. We offered testimony at the February 9, 1983, Senate Armed Services Committee hearing in support of preparation of an EIS before restart of the L-Reactor. At that time we contended that the Environmental Assessment was inadequate, that the Savannah River Plant and its nuclear production facilities were sited back in the fifties, not on the basis of the most environmentally suited area, but on the basis of political acceptability. No comprehensive environmental impact study has ever been done. We seriously doubt, if a study as mandated by the National Environmental Policy Act of 1969 had been required, that this facility would have been sited in a seismically active area of high rainfall, on top of a major aquifer, and impacting a river used as a drinking water source for a large number of Georgia and South Carolina citizens. Those considerations still prevail. There is still need for such a comprehensive study which would take into consideration the impact of the total facility plus the impact of other nuclear operations under the control of the Nuclear Regulatory Commission adjacent to or in reasonable proximity to the Savannah River Plant. Cumulative environmental and health effects need to be considered. Unfortunately, under the terms of an expedited EIS process for one reactor, evaluation of the true broad and long-range impact will still not be adequately addressed. In many respects, the ability of the citizens of South Carolina and its regulatory agencies to deal with DOE has greatly improved since the February 9 hearing. This scoping meeting and the EIS are the result of the amendment to the Energy and Water Development Appropriations Act of 1984 and the ruling by Federal Judge Jackson in the suit brought by the Natural Resources Defense Council. Various League organizations, including those of Georgia and South Carolina, are plaintiffs in that suit. Judge Jackson ruled that the L-Reactor restart is indeed illegal in that it is a significant environmental action. A ruling on the requested injunction to halt the restart until the completion of the EIS process is still awaited.	NEPA procedures	The Savannah River Plant was sited, constructed and started operations in the early 1950's; this was well before the National Environmental Policy Act of 1969 that required EIS be prepared on major Federal actions.
F2		Cumulative (radiological) effects	Section 5.2.6

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	We at this time want to reiterate that the Environmental Impact Statement should not represent a legalistic charade but a sincere commitment to seek and evaluate pertinent information. Obviously, any Environmental Assessment which led to the finding of No Significant Impact needs to be reviewed, evaluated and expanded upon, with full regard to the input of a broad range of interests, including state agencies, the academic community, public interest groups, and private citizens. We would like to offer some comments on the information supplied by DOE relative to the probable contents of the EIS.		
F3	In the category of production alternatives: It would seem important to re-evaluate the need for increased production and make every attempt to scale down those needs. It is inescapable that the question of the need to produce plutonium is part of the greater ongoing national security debate. If it is indeed essential that plutonium production be stepped up, the viable alternatives should be thoroughly explored in the EIS.	Need	Section 1.1 See Comment D1
F4		Alternatives	Section 2.1
F5	In the category of socioeconomic: A broad consideration of the state needs to be incorporated, beyond the immediate jobs at SRP during construction and as an ongoing operation. South Carolina has tremendous potential for non-nuclear economic and recreational development, much of which could be precluded by real and feared impacts of nuclear activities.	Socioeconomic effects	Section 5.2.1

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF JAMES W. STALLINGS			
G1	I am James W. Stallings, research chemist, retired, from Barnwell, South Carolina. Background qualifications: I practiced chemistry for 46 years with four national companies, research and development in industrial/technical management. Memberships: Fellow of the American Institute of Chemists and the American Men of Science. Authored six U.S. patents.		
	I want to address a matter of what we might call groundwater problems. I've had ten years' experience in the industrial use of chlorinated solvents; namely, trichloroethylene and perchloroethylene. These are subjects of the SRP groundwater contamination, plus, of course, other materials.	Groundwater contamination	Sections 4.1.1.2, 5.1.1.2, Appendix F
	Earlier there appeared an article of mine in the paper. This was entitled "Contamination in Our Tuscaloosa Aquifer." I would like to bring up some points listed in that article and, thereafter, go more specifically to what is being thought of today by me.		
	Tuscaloosa Aquifer contaminants are trichloroethylene and perchloroethylene.		
	The pertinence of the aquifer contamination is seen in the broad voids in the required on-the-job engineering knowledge-ability of the handling of chlorinated solvents. This was a mistake in the first place. This is a problem that has to be faced today, which is enormous. This is with respect to recovery by reclaimative distillation rather than the dumping of waste in the earth.		
	Where the average fellow needs to know something about this, I've given some limited but factual data that should clarify to the interested layman why the aforementioned contaminants proceed through and into groundwater rather than evaporate. You have water entrainment at 8.34 pounds per gallon; perchloroethylene at 13.61 pounds per gallon. Perchloroethylene, for all practical purposes, is insoluble in water. Trichloroethylene is 12.15 pounds per gallon with one-tenth of one gram solubility per hundred grams of water, 100 cc or milliliters.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	Normally, these typical chlorinated industrial solvents are recovered by distillation in a closed system both from a stand-point of economy and to prevent air and water pollution. The earthen cesspool, or seepage basin, offers no more than a waste dump wherein solvent evaporation will be rather insignificant if water is present in the basin, and water would be present in the unsheltered, exposed basin. Thus, with water present in the basin from rain or otherwise, the 12-pound-per-gallon trichloroethylene, or the 13.6-pound-per-gallon perchloroethylene will immediately layer beneath the 8.3-pound-per-gallon water on the bottom of the basin. The complete insolubility of perchloroethylene in water assures that it begins a seepage trail from the bottom of the basin into the ground above the aquifer. Likewise, trichloroethylene will proceed completely after a saturation of any water in the basin to the extent of about 3.8 grams per gallon. Mixtures of trichlor and perchlor will behave as would perchlor in their soil penetration by seepage. We have, of course, a trichlor problem there. We have the greater part of the water in this area -- all of the drinking water in this area and surrounding communities, all of that comes from the Tuscaloosa Aquifer and its, let's call it, aquifer tributaries. You know, I can see no more important matter than to clean up the water, first of all. This is a release here, too, and this is given in the Augusta Chronicle as of July 19, 1983. They call it a water cleaner. This must be something absolutely new, and unless it's something very new, it might be something that we found in a Rube Goldberg book. But how in the world are you going to blow solvent out of water unless it's completely insoluble in it? Why do we think that we can go and blow 50 tons of stuff out of the Tuscaloosa Aquifer, and if we did, it would blow into the air where you have 200 parts per million of trichloroethylene. It's the maximum allowable limit. What do you want people in this area to do, breathe that stuff, too?		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
K-24 G2	Well, we got to find out. I cannot go along with this, and it is not my job to, but I've known DuPont in Wilmington, Delaware, for more than 50 years. I can assure you they have the answers there if they are not in Aiken.		
	The stability of chlorinated solvents is another matter, too. These require stabilizers and these disappear in time. So in all cases in these areas where there's solvent in the ground, you've got perhaps destabilized material. You've produced acids, et cetera.		
	There are solutions to the problem I do not go along with. And as being reasonably intelligent in this area, to say that a water cleanser is the answer down there where we do this for the next hundred years at taxpayers' expense, if we need somebody to do this thing, I think we need to go to an outside source. It used to be the most reliable in the country was Arthur D. Little in Cambridge, Mass. Well, they are still there. Whether they do this or not I don't know, but I would suggest that in this EIS statement, the probable solutions will probably turn out you are going to have to mine this stuff out that is below these basins.	Mitigation measures	Sections 4.4.3.1, 4.4.3.2 See Comment B6
	You will probably have to -- it will probably have to go down the Savannah River on a monitored basis. That's the most practical solution. There might be a means of catalytic decomposition of this to produce HCL hydrochloric acid, and to neutralize that.		
	Lastly, and on a personal basis, I consider that the cleanup of the Tuscaloosa Aquifer is, in itself, more demanding than the startup of the L-Reactor because if what I call the mess at hand is not corrected, there is little chance that this or other sources of contamination will receive the corrective attention required for safe drinking water in South Carolina and Georgia from the aquifer.		
	That's my feelings, and I thank you for being able to express myself.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF MICHAEL F. LOWE			
	My name is Michael F. Lowe. I am Director of the Palmetto Alliance, Inc.		
H1	We are a statewide organization dedicated to advocacy on nuclear waste issues, particularly on nuclear waste. I'd like to associate myself with the comments of the others here today, particularly on the need for nuclear weapons material in the EIS, addressing that subject. But it has come to our attention that DOE has disregarded our remarks before the Armed Services Committee and, again, the scoping of the EIS has omitted consideration of the impact of the additional volume of liquid, high-level wastes that will be generated as a result of L-Reactor operations.	Need	Section 1.1
H2		Radioactive waste	Section 5.1.2.8
H3	We also feel that the ability of the planned defense waste processing facility to handle this additional volume in a timely manner should be considered. The Defense Waste Processing Facility would be required to handle approximately 30 percent more than was originally planned.	Radioactive waste	Section 5.1.2.8
	We believe there are many variables that would make the stabilization and ultimate disposal of this waste uncertain. Those variables include the feasibility to vitrify high-level wastes on an industrial scale, which has not yet been proven.		
	The congressional approval for funding to complete this project, the Defense Wastes Processing Facility, could be in jeopardy given economic conditions in the future and the environmental concerns of both the public and scientific community could lead to further delay in addressing the problem of stabilization and ultimate disposal of high-level waste.		
	In our remarks on February 9th, we said that -- and I would like to reiterate that -- it is unfair, unjust, and unwise to ask South Carolina to tolerate generation of more nuclear wastes in our state, and I would ask that the EIS consider this.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF WILLIAM McDANIELS			
	My name is William McDaniels, and I live in Aiken County, South Carolina. I'm representing no particular organization but I am concerned and I think this has been voiced by the previous speakers here about toxic wastes. I'm concerned about our table water, our atmosphere, and things in general. I am a member of the Sierra Club. I also belong to the American Associations of Retired Persons. I will be Chairman of the National Council of Senior Citizens Corporation nationwide. I don't know enough about this L-Reactor here because I've only been down here about ten months. I have moved from the state of Michigan, but I know what happened in Midland, Michigan, on this reactor there, the Dow Chemical reactor. There was ten rivers poisoned forever, and they will never, never be the same.		
11	I feel that the toxic waste here in South Carolina and for miles out is -- I feel that these contaminants have already got down to the table water, and we know that the table water only moves two inches every 24 hours. We have a very fragile thing here, and we're talking about table water. The same thing applies to ozones that have been destroyed.	Groundwater contamination	Sections 4.1.2, 5.1.1, Appendix F See Comment B6
12 13	First of all, I just wanted to voice my opinion that I'm opposed to the startup of this reactor. I don't think that it is necessary, and I feel, first of all, before you start any other reactor or bringing any other reactor into existence, that we should have more study on the method of neutralizing the waste that comes from these reactors. This is one of my main concerns. I moved into South Carolina not knowing that we had this L-Reactor. I read nothing about it. And, of course, we bought a place here. I was born and raised in Tennessee, and I will not dwell too much on anything in particular here, but I have been working in ecology and have been a concerned citizen and a member of DAPL, Downriver Anti-Pollution League in Michigan, but I have worked in ecology in my spare time, I'd say, for since 1948 and '49.	Need Radioactive waste	Section 1.1 Sections 4.1.2.8, 5.1.2.8

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	I'm concerned for our younger people that's coming along. I will be 68 years old in September of next year, but I want to leave something behind for the younger generation. I don't want to leave a contaminated nation, a world -- I would like to see them survive. I have three children and I have three grandchildren, and I think -- I don't think we are getting enough information or input out to the public, like here, in regards to this L-Reactor. This is about all I have to say. It's nice coming. When I got concerned yesterday, of course, I've had a fall and broke all my ribs, and I would not have probably come out except I read yesterday in the paper, Aiken paper, that there was only one person that spoke in Augusta, so I felt I must make myself present to voice my opinion as a concerned citizen.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF VIRGINIA DYKES			
	I'm Virginia Dykes from Greer, South Carolina. I intended to come to represent myself.		
	I've done quite a bit of research on nuclear issues. In fact, I spent so much time in the Greenville County Library reading government documents that they finally invited me to work there.		
	But I was asked also to present a letter that the Greenville County Democratic Women sent, so I'd like to do that, and then also represent myself.		
	The letter was sent -- we're an organization of about 200 women in Greenville, South Carolina. And on our last meeting we voted unanimously to send this letter. This was before the EIS was decided upon. It went to Dr. Robert Jackson of the Department of Health and Environmental Control of our state and to the Honorable Donald Hodel, Secretary of the Department of Energy.		
	The membership of Democratic Women of Greenville County, South Carolina, has voted to support the position of Senator Ernest F. Hollings and Senator Mack Mattingly in their efforts to require an Environmental Impact Statement before the startup of the L-Reactor at the Savannah River Project.		
J1	It is known that operation of this reactor will flush radioactive cesium into the Savannah River and that millions of gallons of hot water will kill vegetation over a wide area.	Radiocesium remobilization Wetland impacts	Sections 3.7.2, 4.1.2.4, Appendix B, Appendix D
J2			Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
J3	We are also concerned about the contamination of the Tuscaloosa aquifer that has already occurred, and we would appreciate being advised as to what action is being taken by your agency to remove these chemicals from the aquifer.	Groundwater contamination	Sections 4.1.2, 5.1.1, Appendix F See Comment B6
J4	Millions of gallons of high-level wastes have been accumulating in tanks at the Savannah River Project over the last 30 years. These tanks, some of which have leaked in the past, are also	Radioactive waste	Sections 4.1.2.8, 5.1.2.8

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	located above the aquifer. Unfortunately, money has never been made available to solidify and remove this waste to permanent storage.		
	While we agree that employment and national defense considerations are also of importance in this matter, we believe the significant long-term damage to our environment which has already occurred at the facility must be alleviated before the problem is further aggravated by the operation of the L-Reactor.		
	We appreciate your consideration of the concerns of our membership who, as residents of this state, are most closely affected by this situation, and we look forward to your response. Sincerely. This was signed by the Co-Chairs of the Legislative Committee, Dianne Smock, who is an attorney in Greenville, and Libby Yarborough, who is a builder and developer.		
	Thank you.		
	This is my own statement that I'd like to make, please.		
J5	South Carolina has the highest infant mortality in the United States. The people of our state die younger than anywhere else in this country. Our students have the lowest Scholastic Aptitude Test scores. When all three of these indicators are the dead worst in the nation, it points to something in the environment.	Health effects	Sections 4.2.1.6, 5.1.2.5, 5.2.7
	We do have a unique feature in our environment: one of the world's largest reprocessing plants, which has been pouring out radioactive emissions continuously for 30 years.		
	People do not realize that reprocessing produces large quantities of radioactive gases and liquids that are released routinely from the stack and into the river. A normally operating power plant emits about 10 curies of tritium per year, while the Savannah River Plant emits 300,000 curies, or more than all the power plants in the world put together.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	Unlike power plants where the fuel is handled very gently, at a reprocessing plant, this highly radioactive product is dissolved in acid, treated with chemicals, and the plutonium is solidified. Even a government document (Air Cleaning Handbook) calls reprocessing an inherently dirty operation.		
J6	At the Savannah River Plant about 560,000 curies of krypton 85 and 300,000 curies of tritium are released per year, according to government sources. My sources happen to be that I called up the Department of Energy and asked for the officials in charge, and just asked them how much was released. These amounts reflect the plant's normal operations, not including accidents or the addition of the L-Reactor.	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix G
J7	Although these isotopes are difficult to filter and dispose of, improved technology does exist which is not being used currently at SRP. A method using fluorocarbons to capture krypton has been developed at Oak Ridge. Voloxidation is a process that can be used to remove tritium before it becomes diluted with water.	Safety alternatives	Section 4.4
J8	We are told that the hundreds of thousands of curies of tritium dumped into the air and into the Savannah River are harmless, but research papers show that the amounts approved for drinking water may, in fact, be a health hazard. Tritium has been shown to be almost three times as damaging to living systems as are gamma rays at equivalent low-level exposures. Tritium circulates as freely as water within individual body cells including sperm and egg cells where minute amounts can cause genetic damage. Human deaths have occurred from tritium exposure. Tritium has a half-life of twelve years, and all of us now carry a body burden of manmade tritium within our bodies continually.	Health effects	Sections 4.2.1.5, 4.2.1.6, 5.1.2.5, 5.2.7, 6.1.4, Appendix B, Appendix G
	I would like to make part of the official record three research papers on tritium which I obtained from the Duke Medical Center Library:		
	The first is Dr. R. Lowry Dobson, Lawrence Livermore Laboratories of the University of California, <u>How Toxic is Tritium? Relevance of High-Dose Results and Gamma Ray Data to Evaluating Low-Level, Chronic Exposure.</u>		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	The second is Drs. S. Zamenhof and E. van Marthens, Mental Retardation Research Center, University of California at Los Angeles School of Medicine, <u>The Effects of Chronic Ingestion of Tritiated Water on Prenatal Brain Development</u>. The third is Dr. Takashi Ito and Katsumi Kobayashi, University of Tokyo, <u>Mutagenesis in Yeast Cells by Storage in Tritiated Water</u>. One of these papers shows that pregnant rats, when fed with water containing minute amounts of tritium, produce offspring with fewer than the normal number of brain cells. I am suggesting that we can't add 60,000 more curies of tritium out the stack and into the river without doing something about the immense problem we already have, and I think that you do need to make this part of your Environmental Impact Statement. And I think studies such as these scientific papers, when you read something like <u>Tritium Control Technology</u>, a government document, they make passing references to these research papers, but they say it's not practical to remove tritium; it's a very difficult thing. Therefore, it's not being done. They will even say the reason that tritium emissions are accepted is that they are so difficult to remove.		
J9	Well, I'm saying we got to address this question, and this is the time to do it. When we're having an Environmental Impact Statement is our golden opportunity to see what has tritium done in the past, what is it going to do, what are the further emissions going to do to us in this state.	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix G
J10	Other nations have not located their large reprocessing plants where emissions are released into the air and drinking water of the population. France, England, and Japan have located their reprocessing plants on the edge of the ocean. France has a long pipe along the ocean bed to carry waste a safe distance out. Dumping radioactive waste into the ocean isn't a wonderful solution, but it is better than putting it into a river that is used for drinking water.	Radiological effects	Sections 5.1.2, 5.2.6
J11	It is not possible to relocate or shut down the Savannah River Plant, which employs 8,000 people and which is needed for defense, but the concept of laying a waste pipe down the full	Radioactive waste	Sections 4.1.2.8, 5.1.2.8

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	length of the river and out to sea should be examined. The coastal communities may not like it, but it is better for them than the present system which releases radioactive materials upstream and upwind.		
	Moving the waste by pipeline out to sea may be more practical than a closed circuit cooling system at SRP, given the problem of cooling water becoming more radioactive every time it recycles through the plant.		
J12	Studies should be made for the EIS comparing infant mortality and other health records of communities downwind and downstream from SRP with towns in the opposite direction.	Health effects	Sections 4.2.1.6, 5.1.2.5, 5.2.7, 6.1.4, Appendix B
	The accidental release of 479,000 curies of tritium in one day in 1974 presents an opportunity to examine infant mortality in the following year in the path of the radioactive release.		
J13	The additional emissions from the L-Reactor cannot be accepted without adequate controls when SRP already produces one of the greatest concentrations of radioactive pollution of any location on earth.	Regulatory requirements	Chapter 7

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF JOHN DENTON			
	My name is John Denton. I'm a concerned citizen from North Augusta. I have a Bachelor of Science from Western Carolina in 1936. I never worked for the government or DuPont either, and I have no DuPont stock.		
	I've heard the meeting with Dr. Thurmond and in -- Senator Thurmond had in North Augusta, and quite a few comments. I think there's a lot of confusion that really isn't necessary. We need to be well informed on this matter. We need whatever information that is necessary, but some of the figures and things that were asked for and seem to be required, I'm sure Russia would like to have that information.		
K-33	This reminds me of when I was starting up a plant in Baton Rouge, Louisiana, a few years ago when the media and various people worked people into a fanatic state when the chlorine barge was dumped into the river by the hurricane. On the morning that the barge was raised, according to the TV, 20,000 people fled the city. I couldn't get enough men to start my unit, and the danger was equivalent to the possibility of you falling out of bed tonight and breaking your neck.		
	Now, that seems to me to be somewhat of the case in this L-Reactor startup. I have worked all over the world. The United States is the greatest nation in the world. War is a terrible spectre for me. I saw a few shells come over in World War II, and I don't like it. I'd hate to see a nuclear holocaust, but whose choice is it? The United States has never been a nation to go to war on its neighbor. In fact, it has a record of helping everybody all over the world.		
	Now, we need that L-Reactor. We need to get it going. Some people question that, and maybe honestly, but we can't get this information from Russia, what they're doing over there, and we need to -- we need to get on with it.		
	I know a lot of people that work for DuPont, probably 8,000 people out there, and for each one of those people that work out there, there's five or six supportive occupations in this		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
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area. They can't be here today to voice their opinion about it.

We have a certain number of groups that come down here like flies on a warm biscuit with jelly on it and try to push their ideas down our throats. I don't agree with that. We should go ahead and start that reactor. Sure, we need the information, but three to five million dollars for an Impact Statement, it's our taxes. I've been paying taxes since 1936. I've never drawn unemployment or welfare, and I'd like to see my taxes well spent. If we have to have that, go ahead and get it, but let's get this reactor started.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF BEATRICE JONES			
	I am Beatrice Jones, I have no affiliation, but I am a concerned citizen.		
	With regard to the present serious environmental circumstances at the Savannah River Plant, there should be no more errors that underestimate, or decisions that intentionally downplay, the dangers of environmental impacts of the public health and safety.		
L1	Concerns about radiation discharges to the environment, both routine and accidental, continue to be taken lightly by the DOE even though they know full well there is no evidence for any safe amount of ionizing radiation.	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix D, Appendix G
L2	The restart of the L-Reactor is an anti-social, ill-considered, technological venture that does not seriously take into account the health and safety of citizens in South Carolina and Georgia, or the protection of a fragile environment.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7
	Decisions to move forward with the L-Reactor were made by men who should understand that they will be held accountable for their decisions. As I have said before, it is immoral to put a low dollar value on human and other life forms in South Carolina and Georgia, while pushing hazardous technology where there is already too much.		
	Morality, however, is not likely to visibly enter into Savannah River Plant technological considerations, at least not until mechanisms of rationalization no longer surface so abundantly to protect even the most obviously indefensible positions.		
	I have serious reservations about whether an expedited EIS can adequately address the L-Reactor's impacts, particularly when almost all the problems at SRP are interrelated and were brought to a head by the L-Reactor. The EIS study should be done in relation to the past 30 years of operational impacts, that would take into account the errors of the past, so that they won't become the errors of the future as well.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
L3	I am not at all certain that the time element for restarting the L-Reactor is as crucial to national security as is claimed, but rather the DOE's fears of too much environmental impact disclosure.	Need	Section 1.1
L4	Nevertheless, even though the expedited EIS will be far less than what is needed, every effort should be made for a complete as possible, honestly disclosed, evaluation of the L-Reactor's environmental impacts. The DOE's own reports contain projections of severe environmental impacts without mitigation measures. It is comforting to know that Senator Hollings has asked the General Accounting Office to review certain health and safety issues, which have for some time been my own concerns, as well as those of many other people in South Carolina and Georgia.	Mitigation measures	Section 4.4
L5	The scope of the EIS should certainly include the routine and accidental radiation hazards at SRP. It is an area of concern, perhaps the biggest area of concern, for many people. Also, perhaps the most far-reaching. The body dose to individuals from the L-Reactor's startup would increase from 1.8 to approximately 10.7 millirems per year. Twice NRC standards.	Accident analysis	Sections 4.2, 4.3.2.3, 4.4.1, 4.4.5, Appendix G
L6		Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B
L7		Health effects	Sections 4.1.2.6, 5.1.2.5, 5.2.7, 6.1.4
L8	The restart of the L-Reactor would substantially increase the cumulative hazards of radiation, and because of its age, will very likely be more accident prone, releasing even greater quantities of radioactivity to the already overburdened environment. Containment domes should be required for the L-Reactor and all other operating reactors at the Savannah River Plant.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
L9		Safety alternatives	Section 4.4.1, Appendix G
L10	Clearly, the impacts of the seepage basins to groundwater should also be another of the most important parts of the EIS	Seepage basins	Section 4.4.3 See Comment B6

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
L11	scoping. The enormity of the known contamination, and the potential for even greater contamination has reached almost nightmarish proportions. It is obvious that all seepage basins still in use should be phased out as soon as possible, and those at the L-Reactor site should not be put to use. Government should have been preventing these things from happening instead of making them happen.	Groundwater contamination	Sections 4.1.2.2, 5.1.1.2, 5.1.1.4, Appendix F See Comment B6
L12	As we all know, toxic chemicals from seepage basins in the M area have contaminated the Tuscaloosa Aquifer, a major source of fresh water in the area. The DOE's earlier assessment of the problem indicated the problem was under control, but their assessment was inaccurate. Earth has functions other than to serve as a nuclear sewer.	Seepage basins	Section 4.4.3 The contamination of the Tuscaloosa Aquifer will be the subject of a separate NEPA document.
L13	It appears to me that it would be helpful if the U.S. Geological Survey would be permitted to go on site to do a detailed hydrological and geological study. I believe it is more difficult for government officials with conflicts of interest to assess problems with the proper perspective. It is every person's authoritative right to protect the purity of their drinking water. Government should not only respect, but help to protect this right.	Groundwater contamination	See Comment L12
L14	For the avoidance of illegal 174 degree Fahrenheit thermal discharges into Steel Creek, cooling towers should be put into place before the L-Reactor's start-up. Without the benefit of cooling towers, all wildlife in the wetlands will be destroyed, fish in the Savannah River will be killed, and the cesium in the water will pose a serious threat to the health of people who drink Savannah River water. This is another issue which concerns me greatly, and one that I would like to see addressed.	Alternative cooling	Section 4.4.2 See Comment E6
L15	I am concerned about all 11 of the issues listed in the "DOE News," and appreciate your efforts for the scoping meetings. I do feel, however, that so many people voiced their concerns and suggestions during the February and May hearings, that there is little else to do but reiterate what has been said before. The areas of greatest concern are obvious.	Radiocesium remobilization	Sections 3.7.2, 4.1.2.4, Appendix B, Appendix D

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
L16	I hope all the issues will be given serious attention and mitigation measures taken into account, because constructive action is possible to protect lives, health and the environment. I would like to take just another moment to make a few suggestions not related to the EIS.	Mitigation measures	Section 4.4
L17	1. Monthly measurements monitoring reports should be made public. 2. All notifications of accidents at SRP that are filed with the Energy Department on radioactivity or chemical substances should be made public. 3. There should be off-site gamma measurements by aerial surveillance as well as the on-site measurements. 4. Any health effects researched should be done by a Federal Public Health Agency. As taxpayers, we support these agencies that are supposed to protect us.	Monitoring	Sections 6.1, 6.2
L18		Emergency planning	Appendix G, Appendix H
L19		Monitoring	See Comment 88
L20		Health effects	Section 6.1.4

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF BARBARA WISE			
	My name is Barbara Wise, and I'm an area resident.		
	I'd like to preface my comments with the fact that I am a lay person, I haven't spent much time on the technology involved in the scope of an EIS. What I will tell you today is what my personal concern is, and I'm not sure but I hope that it will be within the scope of the EIS.		
	I want to give a brief summary of the concerns I would like to see addressed in the EIS.		
K-39	M1 First, how am I at risk as an area citizen and how am I to be informed of my risk? I and the other citizens who live in the environs of the Savannah River Plant are taxpayers. We help to fund the operation of Savannah River Plant. We have the right to know how we and our children and our environment are put at risk by the start-up.	Accident Analysis	Section 4.2.1, Appendix G
	M1a	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix H
	M2	Emergency planning	Appendix H
	M3 I would like to know how the L-Reactor releases and wastes will affect us when combined with and added to the ongoing releases and wastes already occurring at SRP.	Cumulative radiological effects	Section 5.2.6
	M4 I would like to know about the synergistic effects of the total radioactive releases from the Savannah River Plant, including L-Reactor releases, when combined with the urban and industrial chemical pollutants to which we are already subjected.	SRP and regional effects	Section 5.2.6 The cumulative radiological effects from SRP are small (EIS Section 5.2.6) and no synergistic effects are expected.
	M5 In addition to this, what are the predictable increases in accidents, so-called incidents, and problems we can expect with regard to this restart? I have grave doubts that we will be informed in any meaningful way of any of these dangers because we haven't been in the past. It's true that information is published sometimes and maybe and usually is buried in other technical data in some report or article somewhere, but without any explanation of real implications that ordinary people can understand.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
	Things are always within safe parameters, it seems, at SRP when you hear any comments from the Department of Energy or other satellite agencies.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
K-40	I'd like to cite one example. In 1977 there was an accident at which time a massive amount of radioactive tritium was released into the environment, 479,000 curies of tritium were released in one single day. The ordinary lay person cannot interpret this. What is a curie?		
	To give perspective on this, approximately one half this amount, 250,000 curies was released in 1979 at the tritium facility in Tucson, Arizona, at which point the State of Arizona revoked its license. To know that the American Atomic Tritium facility is shut down because it released approximately one-half the amount in a year that SRP releases in one day is one way to give perspective to otherwise meaningless technical data.		
	I know from my reading, and there is agreement among the experts that there is no safe level of ionizing radiation. Cancer deaths and fetal deaths and genetic mutation will occur in direct ratio to dosage received. Yet, there have been no comprehensive health studies around here to address this problem.	Health effects	Section 6.1.4
	I understand that this is probably not in the scope of an EIS, but what could be more relevant than health effects on humans in an Environmental Impact Statement. We're at least as important as the Sturgeons. That is what needs to be done most of all, and if that is beyond the scope of an EIS, then the EIS should demand that a comprehensive health study of radiation effects on humans be begun immediately in addition to the EIS.	SRP and regional effects	Section 6.1.4
	Until that time, we, the area residents, are functioning in the role of laboratory animals in this ongoing nuclear experiment. Given the choice, I would prefer to be an informed laboratory animal.		
M8	In a final remark, I would like to express my concern over the fact that DOE is doing any part of that Environmental Impact Statement. Now, I know they have been charged to do it, but it seems to me in my lack of knowledge of these things that it is inherently improper regulatory practice for an agency to regulate itself, nor is DuPont or any other benefactor, affiliate, or satellite of SRP an appropriate designee to conduct the EIS. The conflict of interest is blatantly obvious.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	If you are in the primary business of production, you can be assured that protection will be compromised and we have only to look at the record to know this. I guess what I'm requesting is that there will be some mechanism built into the EIS to enhance objectivity.		
M9	Last, I would like to request that the EIS draft be given the full 45 days as is the usual procedure.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF MARY LOU SEYMOUR			
	Okay, I'm Mary Lou Seymour. I live in Bath, South Carolina, about, oh, ten miles from here, and I'm just a concerned citizen.		
N1	I haven't really got anything very prepared, but I have a few points that I'd like to bring out. In the first place, from what I understand, the Savannah River Plant is allowed to put much hotter water into the creeks than the other local industries and doesn't have to abide by the South Carolina State laws, and I don't think that's right. I think that should be changed. They should have to abide by the state laws like other industries, government or not.	Regulatory requirements	Chapter 7
N2	Also, I agree completely with Ms. Wise's point about the health study. A full epidemiological study should be made. There never has been one made, and it's just beyond comprehension that it hasn't been. The Savannah River Plant has been there for like over 20 some-odd years, and there, you know, could be plenty of data on birth defects, cancer, leukemia, and the like, that should be collected and given to the public so we can know what we are living with out there.	Health effects	Section 6.1.4
N3	Also, one note on the civil defense or whatever you call it when people are supposed to be notified to evacuate. This last accident or leak incident or whatever it was they had a couple of weeks ago, I heard about it on the national news. It wasn't on any local news at all, and I was kind of upset, so I called up the Civil Defense emergency number in Aiken County, and they had never heard of it. And I talked to one lady on the phone, and then she got, I suppose, her boss in, and he told me, "Well, don't worry about it because I'm sure if it was anything they would have told us."	Emergency planning	Section 4.2.1.3, Appendix G, Appendix H
	And then I read in the paper later on that the leak happened like at 11:15 at night, and they didn't even tell DHEC until 12:45. That was like an hour and a half that nobody knew about it, not even DHEC, and then the citizens didn't know about it at all unless they watched the national news, and I think that's inexcusable.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
N4	Also, there's one comment that I heard on the news. I didn't make the hearings last night, but one of the people that testified mentioned the possibility of a melt-down, and someone from the Savannah River Plant or DOE or somewhere said that these reactors are different than commercial reactors, that they can't melt down because they don't get hot enough. Well, now, I'm not a scientist, but I thought a melt-down was when it went out of control. I didn't know it had anything to do with the operating temperature. Now, if I'm wrong there, you know, I would appreciate knowing. It's just like you are living in ignorance all the time, and you feel like, you know, I mean, I hope everything is going okay out there but they don't tell you about it when something happens. Like Ms. Wise says about "I'd rather be an informed laboratory animal," I mean, it just makes you feel better at least to know what's going on. I don't think there would be any panic caused if we had just been told to close our windows, that a cloud of tritium might be going by, just close your windows or something, don't go out. I mean, we had friends over at our house and they left about when it happened, at 11:00 o'clock at night, and I thought about that. Like I say, I am not a scientist but if there is this much concern about it, apparently the whole place was covered with people from DOE and NRC the next day out gathering samples in helicopters, it must have been something fairly important or they wouldn't, I don't assume, wouldn't have spent the money to do all of that.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
N5	And just one thing I would like to see in the Environmental Impact Statement, is to take it really seriously. I mean, it just seems like it's taken, you know, a lot of people fighting a long time just to get to this point, and it seems like that should just be done automatically, and I certainly think it should get the full 45 days it's supposed to, and not be cut down to 30 days. And that's it.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF DR. ZOE TSAGOS			
	My name is Zoe Tsagos. I hold the Energy Chair in the League of Women Voters of Northern Beaufort County.		
	I speak in behalf of our organization which is a participant in the suit, in part pending, against the Department of Energy.		
	On July 15, 1983, United States District Court Judge Thomas Penfield Jackson ruled on the first part of the suit brought by the National Resources Defense Council and others for the issuance of an Environmental Impact Statement by the DOE before the restart of the L-Reactor at the Savannah River Plant.		
	The previous day, July 14, the President signed the Energy and Water Development Appropriations Act, FY-1984.		
	For greater clarification, I quote from H.R. Report Number 98-272, 99th Congress.		
	And, I'm doing this, or I thought I would be doing this because people would be here, especially numbers of people, who might not have been following this whole matter.		
	But, nevertheless, I think it's pertinent. The pertinent section of this Act reads as follows:		
	"None of the funds appropriated by this Act, or any other Act, or by any other provisions of law, shall be available for the purpose of restarting the L-Reactor at the Savannah River Plant, Aiken, South Carolina, until the Department of Energy completes an Environmental Impact Statement pursuant to Section 102(2)(C) of the National Environmental Policy Act of 1969, and until issued a discharge permit pursuant to the Federal Water Pollution Control Act, 33 U.S.C. 1251, following, as amended, which permit shall incorporate the terms and conditions provided in the Memorandum of Understanding, entered into between the Department of Energy and the State of South Carolina, dated April 27, 1983, relating to studies and mitigation programs associated with such restart."		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
K-45	The purpose of today's meeting by DOE is, as we understand it, to hear suggestions on what the EIS should encompass, a scoping operation based, in part, on public recommendations from previous hearings and written submissions. Because of the limitation of time and because we realize that comments will be forthcoming in each of the eleven categories, from various sources, we shall confine ourselves to five recommendations which lie within one or more of the DOE listed areas. 1. Lying within the scope of Number 10, Cumulative Thermal Effects of discharging scalding radioactive effluent into Steel Creek and the Savannah River. And, Number 11, Cumulative Radiological Effects of emissions, both in the atmosphere and in the water.		
	01 We strongly recommend that a method of cooling the reactor effluent be introduced, either by recycling, by cooling pools, or by any other acceptable method which will cool the emissions to the standard of 90 degrees Fahrenheit, acceptable to the South Carolina Department of Health and Environmental Control.	Alternative cooling	Section 4.4.2 See Comment E6
	2. Our second recommendation has to do with the use of seepage basins or containers, and falls within both Number 4 in the DOE identification of issues, which has to do with groundwater usage and the drawdown into the Tuscaloosa Aquifer, as well as Number 9, which concerns itself with groundwater contamination through seepage basins.		
	02 We feel that new means of containment of radioactive and non-radioactive chemical wastes should be devised, and that frequent and thorough inspection is necessary of whatever receptacles would be used to prevent groundwater seepage as in the case of the contaminated wells and the penetration into the Tuscaloosa Aquifer of the cleaning agent Triclene.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F See Comment B6
	03 3. Our third recommendation would touch upon all eleven areas listed by DOE. We feel that the present method of yearly environmental monitoring of the Savannah River Plant by DuPont, which prepares the study for DOE, would be better carried out by a carefully chosen independent commission, an independent body not connected with DuPont or with the Department of Energy	Monitoring	Sections 6.1, 6.2 See Comment B8

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	or with any other group involved with the operation of the Savannah River Plant. This is not necessarily a reflection on the work done and the contents of the DuPont report, whose full title is: Environmental Monitoring in the Vicinity of the Savannah River Plant. And, the one I have is as late as 1982. Obviously, information from those who operate the Savannah River Plant is valuable; however, taken together, the material required by government agencies, such as DHEC, the data that can be provided by DuPont and the independent observation of a public commission, would provide a report which would be as inclusive as possible, and which, incidentally, would spread the responsibility about the accuracy of the environmental impact information.		
04	4. Our fourth recommendation lies within the area of safety; Number 7 in the DOE list. Neither in the Environmental Assessment nor in the Environmental Monitoring Study is there an evacuation plan presented. In the EA under "Reactor Accidents," pages 4-26 through 4-31, covering nuclear, non-nuclear and accidents due to natural causes, there is a reference made to an evacuation plan. A reference only. On page 4-28 under "Risk Evaluation," the following statement is made: "An emergency response plan has been implemented at the Savannah River Plant to initiate actions or evacuation of employees during an emergency." We feel that with the putting in operation of a fourth reactor at the SRP, thus increasing the possibility of an accident, an evacuation plan should be included in the EIS showing the steps to be taken to evacuate not only the people in the SRP, but also the people which can be affected outside the production site.	Emergency planning	Section 4.2.1.3, Appendix G, Appendix H

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	An article in the New York Times of June 5, 1983, states the following: "In case of an accident in a nuclear plant, the Nuclear Regulatory Commission requires that preparations be made that those living within ten miles can be notified, sheltered or evacuated. "Plans must also be made to test for contamination of the food and water within 50 miles." This applies to commercial nuclear plants. But, an accident would be equally destructive whether it occurs in a commercial or federal installation. We, therefore, need to know what steps will be taken at the SRP in case of an accident. It should be spelled out.		
K-47 05	5. Our fifth recommendation rests squarely on the DOE issue Number 11, Cumulative Radiological Effects. We are disturbed at the present plan to restart the L-Reactor before the glassification or solidification plant will be in operation. We strongly recommend that serious consideration be given not to start the L-Reactor until the means of solidifying and removing the radioactive isotopes is available, thus making the effluent from the reactor far less destructive to the environment and less polluting of the Savannah River drinking water for 70,000 people. In summation, we are glad that an EIS, even an expedited one, will be prepared, not only because this was a pivotal point in our suit against DOE, but because both the people involved in the suit and the people who will be operating the L-Reactor will have time to take yet another look at the information which has been gathered in the testimony in North Augusta and at the several DOE hearings. This, we hope, will be an opportunity for a reappraisal and a sincere attempt by all of us to bring about the best possible solution to a difficult problem.	Radioactive waste	Sections 4.1.2.8, 5.1.2.8

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF SISTER HELENA PRICE			
	My name is Sister Helena Price. I am a member of the Religious Order of Sisters of Christian Doctrine, located in Suffern, New York. I am presently employed at St. Peter's Catholic Parish, located here in Beaufort. My main work consists in facilitating Religious Education programs, as well as serving the social needs in the local community.		
P1	I, along with many others, all interested citizens, object as well as fear the restart of the L-Reactor in the immediate Savannah area. We feel deep concern for the possible health hazards it could create, as well as the environmental destruction we could experience.	Health effects	Sections 4.1.2.6, 5.1.2.5, 5.2.7, 6.1.4, Appendix B, Appendix G
	We are in complete agreement with the federal judge's decision that an Environmental Impact Statement be made before the L-Reactor is restarted.		
	I, and those with whom I have spoken about this issue, hope that the Environmental Impact Statement will leave no doubts about the possible dangers for us and for succeeding generations to come.		
	That completes my statement.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF SUSAN GRABER			
Q1	I'm Susan Graber. I drink the water and I'm here for that reason. I'm thrilled, as all of us here in Beaufort are, that an EIS is going to be done, and I just wanted to point out one thing, that I just hope that you would consider taking into consideration the entire water problem that we have in this area. There are threats to our groundwater that concern us, saltwater intrusion, overuse and overpumpage creates problems, and I would just hope you would take into consideration our water problem in its entirety and what the elimination of our surface water source would do, you know, considering our groundwater problems as well.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F See Comment B6
Q2	I don't know if you have the Metropolitan Savannah groundwater study that the Corps of Engineers did, but if you would look at that and just consider the little bit of a tussle we are having with Savannah over our groundwater, okay, and how damage to our surface water would really greatly affect us on the coast.	Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2, Appendix D

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF ZAIDA DILLON			
	I'm Zaida Dillon, and I have no affiliation, and I'm here as an individual to express my own personal delight with the fact that there will indeed be an EIS.		
	Addressing the issue of purity of air and purity of water for Beaufortonians who consider themselves very close downstream from the Savannah River Plant.		
	Although I speak as an individual, the end of 1982, one thousand signatures were gathered from citizens in Beaufort by a group of us in Beaufort who are unaffiliated with any organization or political group, and in February, the signatures regarded the importation of high level nuclear wastes into South Carolina. However, I think there was hardly an individual who signed that petition who did not in addition make a comment about the fear of the threat of the Savannah River Plant as being a possible hazard to air and water, and these thousand signatures were presented personally to Secretary Hodel, in his office in the Forrestal Building, so I think that although there are very few people as citizens here tonight, I assure you that those thousand people, silent voices, are out there in Beaufort.	Atmospheric effects Groundwater contamination	Sections 4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, Appendix B Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F

K-50

R1
R2

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF ANN HARRINGTON			
	My name is Ann Harrington, and I'm just speaking as a private citizen. I have something written, so I will read it. Since your last hearing, I have been thinking of what I would like to say to the decision makers concerning the L-Reactor as well as the nuclear issue in general. It is my feeling that you are all good people concerned with doing what is best for our nation and our children's future. I have no choice but to trust that you are competent, conscientious professionals. The ton of paperwork you have here assembled generated by your countless hours of research and the hours upon hours spent in research leave a layperson, like myself, little room to argue on any of the technical points. However, I have read some on the subject and reflected on it and have come to my own conclusions.		
S1	What we are concerned with here are environmental consequences, and I have one question that I wish someone could answer. Why, after 30 years of nuclear weapons and power development, is there no program for permanent storage of nuclear waste? I feel that it is foolish to continue to provide waste until a safe, permanent solution has been developed. Until this has occurred, I call for a freeze on any further production of nuclear weapons and nuclear power plants. I want you to know that I am afraid. I wonder if the day is coming when an accident at SRP will force us to evacuate our homes, never again to return. A catastrophe of this magnitude could cripple our country economically and destroy countless lives. Do we really need to take such a risk? Ultimately, you are to decide that. I hope you think long and hard on it.	Radioactive waste	Nuclear Waste Policy Act of 1982 established responsibilities, procedures, and schedules for providing permanent storage of high level radioactive waste.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF GERALDINE LEMAY Mr. Cumbee, Mr. Sires, I am Geraldine LeMay, Chairman of the National Resources Committee of the League of Women Voters of Savannah-Chatham County and formerly Chairman of the Energy Committee of the League of Women Voters of Georgia. Mrs. Lee Wash, President of the Georgia League, has asked me to represent her in speaking for the state League at this hearing. Care for the environment is a major concern of the League, and the League of Women Voters of the U.S. in its policy toward energy development and implementation takes the position that "environmental protection is a primary consideration." This will be the major emphasis in my suggestions about the L-Reactor reactivation. Perhaps I should comment first on my previous appearances at Savannah River Plant hearings. I am today for the third time speaking for the Georgia League at a public hearing on the proposed reactivation of the L-Reactor at the Savannah River Plant. My earlier statements, at meetings in February and May, were concerned specifically with the need for an Environmental Impact Statement. Happily, there will be no need to restate today those arguments, for an EIS is now being done. DOE is now in the progress of preparing such a statement. I am most pleased that we have thus progressed to the position of doing a thorough study of the impacts on the physical and human environment before the final decision is made on whether to complete reactivation of the L-Reactor and place it in operation. Some recommendations on the process of developing and desirable goals for the EIS: My concern is that the EIS be done in such a			

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
T1	way that it both will be recognized as an adequate scientific analysis, and one which is truly objective. The EIS should not bring forth the kinds of criticism which the DOE's Environmental Assessment has aroused, of a biased approach, one too limited in scope, and perhaps sometimes inaccurate when at variance with other studies made of the area.	NEPA procedures	NEPA procedures require that the responsible agency ensure the professional integrity of the discussions and analyses in EISs. DOE has identified methods used and has made explicit references to the scientific and other sources relied on for conclusions.
T2	The goal stated above, in my opinion, might best be reached by DOE's establishment of an independent advisory committee to oversee studies and mitigation measures. Such a committee, with details on its possible makeup and responsibilities, has already been recommended to DOE by the plaintiffs in a lawsuit about the EIS. The proposed committee would be widely representative of all interested groups, having members from federal, South Carolina and Georgia governments, the plaintiffs, and other civic and environmental groups. On such a committee, there would be adequate scientific knowledge and sufficient representation of the public interest to assure that the EIS would both be and be recognized as adequate, accurate and objective a goal which I think DOE would want and should try to achieve. And now about the scope of the EIS as proposed by DOE: DOE's notice of intent to prepare an Environmental Impact Statement lists 11 issues which will be analyzed and suggests that others may be added following the public hearings. This indicates, commendably, a desire to include all aspects of the problem in the study. However, because of the short time in which this particular EIS is to be made, it may not be possible to cover adequately this broad a field, and some issues, although all listed by DOE are important, may have to be dropped. Issues finally chosen for study, if some do have to be dropped, should logically include those which a number of interested groups have pointed out as essential: First, human health effects; reactor safety and radioactive emissions; groundwater contamination; groundwater usage; thermal effects; transportation of radioactive materials.	NEPA procedures	Foreword.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
T3	And, now, comments on proposals for mitigation of potentially harmful impacts: Certain proposals for mitigation of potentially harmful environmental impacts from the L-Reactor reactivation have been strongly urged by interested civic and environmental groups. Many of these suggestions are also among alternative mitigation measures proposed by DOE in its notice of intent.	Mitigation measures	Section 4.4, Appendix I
T4 T5	For reactor safety: An improved confinement system; a containment dome; adoption of safety standards imposed upon commercial nuclear power plants.	Safety alternatives Regulatory requirements	Section 4.4.1, Appendix G Chapter 7
T6	To prevent groundwater contamination: The elimination of the use of seepage basins.	Seepage basins	Section 4.4.3 See Comment E6
T7	To reduce groundwater usage and thermal effects: The use of a recirculation system for the cooling water.	Cooling alternatives	Section 4.4.2
T8	For safe transportation of radioactive materials: Adherence to standards imposed on commercial nuclear activities. DOE should, I suggest, give special consideration to these methods of mitigating the potential harmful effects of the L-Reactor reactivation.	Regulatory requirements	Chapter 7
T9	What is, to me, the determining factor in the decision on reactivation of the L-Reactor: In concluding my remarks, I should like to say that the near completion of the renovation of the L-Reactor should not, in my opinion, be a determining factor in the decision on its reactivation.	Need	Section 1.1
T10	If the EIS does point to the likelihood of serious harm to people and to the physical environment, the L-Reactor should not be put back into operation. The health and safety of the people who live and work in the area should be accepted as infinitely more valuable than the millions of dollars invested in an idle nuclear reactor. The L-Reactor should not again be placed in operation if doing so will lower the quality of life for the people who live in its immediate area, in South Carolina and Georgia, and along the Savannah River below the plant site.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, 6.1.4, Appendix G

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF LAWRENCE BENEDICT			
	It's nice to be here again. I am Lawrence Benedict. I am the Chairman of the Environmental Quality Committee, League of Women Voters, Savannah-Chatham. We thank you for allowing us input into this very vital Environmental Impact Study the department is conducting.		
	After hearing Geraldine LeMay, and I hope, Virginia Brown, you are well aware of the League's position regarding energy development, which is that environmental protection is a primary consideration. You are equally aware, I'm sure, that the League is not alone in this position, nationally and regionally.		
	Here, in what is darkly called "SRP Country," we particularly support the similar position of two of our co-plaintiffs in recent victorious lawsuit, which compelled the Department of Energy to conduct an Environmental Impact Study prior to re-starting the Savannah River Plant's L-Reactor.		
	Further than that, we speak today on behalf of The Georgia Conservancy and Coastal Citizens for a Clean Environment, representatives of whom have been called away on long-planned vacations.		
	The primary concerns of these organizations are these:		
U1	Number One, the findings of the EIS should be thoroughly documented; that is, how did the conductors of the study reach particular conclusions, such as thermal effects in the Savannah River, or amounts of cesium to be released, et cetera.	NEPA procedures	Foreword
U2	Number Two, the cesium levels in Steel Creek Delta should be retested, not simply recalculated.	Radiocesium remobilization	Sections 3.7.2, 4.1.2.4, Appendix B, Appendix D
U3	Number Three, DOE should also produce documentation of the real need for the materials to come from the L-Reactor, without this information creating a national security risk.	Need	Section 1.1

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
U4	Both The Conservancy and the CCFCE have questions about who will prepare the EIS. Both register reservations about the NUS Corporation continuing to serve DOE in environmental matters because of that company's Finding of No Significant Impact in the neighboring environment as reported in the flawed Environmental Assessment. You will recall, in the above-mentioned lawsuit, U.S. District Court Judge Thomas P. Jackson denounced the FONSI as "unreasonable, arbitrary and an abuse of discretion." The League concurs. But forcing DOE to conduct an EIS is only part of the victory in the Court. The Court's decision becomes even more significant than a presidential signature on an appropriations bill because, according to Attorney Jacob Scherr of the Natural Resources Defense Council, Inc., "It makes clear that DOE was acting in violation of the law and sets a precedent for DOE's decisions in the future regarding the Savannah River Plant."	NEPA procedures	Foreword
U5	And because there was a violation of the law in attempting to restart the L-Reactor, the League will continue to press the fight to win an injunction to halt the restart until all concerned are satisfied that the need for the reactor is matched by mitigating measures to protect the health and well-being of all the creatures and plants in SRP's surrounding area. Given the seeming willingness of DOE to comply now with the law, the signals we citizens get from SRP are that the whole system has been approaching a state of disaster in its latter years of a very large nuclear-materials-producing life. The components for disaster have been visible since the first cascade of scalding discharge water wiped out the marshes and denizens of Steel Creek Delta back in the fifties. Permanent radioactive damage was assured when the cesium it carried with it became an integral part of the delta's mud. Another of SRP's disaster components was registered, for the first time, last spring when it was discovered that discharged toxic liquid wastes were leeching through some of DOE's collecting ponds into the area's groundwater supplies, the extent to which has not yet been determined.	Mitigation measures	Section 4.4

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
	And lately, just a few weeks ago, DOE announced the escape of a small quantity of tritium into the atmosphere. "A paltry supply it was," implied a DOE official. "No more radioactive material than one experiences every day flying at 30,000 feet." Nonsense. We are unconsolated by such analogies and turn instead to recent scientific studies which suggest that routine and accidental releases of tritium may be more hazardous than previously believed. Tritium is radioactive hydrogen which can combine to make radioactive water. This radioactive water becomes an unseen hazard in our rain, our rivers and eventually our food. These studies suggest that a dose of radiation from tritium may be three times as damaging as the same dose from x-rays. When tritium becomes a part of our food, our bodies are more likely to retain it. While tritium is inside our bodies, it bombards our body cells with radiation that can cause damage which can lead to cancer and other health problems. The unborn child is especially sensitive to damage from tritium, and young children are more sensitive than adults. The bibliography that goes with that is from HEALTH AND ENERGY LEARNING PROJECT, 236 Massachusetts Avenue, Washington, D.C.		
U6	In closing, let me restate the League believes strongly in mitigation measures to correct the deficiencies in SRP's antiquated equipment. In our view, the real issues are not how little radioactivity is abroad in SRP's neighborhood, not how significant is the destruction of Steek Creek's ecology as compared to the rest of the marshlands and wildlife in Georgia and South Carolina.	Mitigation measures	Section 4.4, Appendix I
U7	The real issues are what caused the accidents at SRP and what is being done to prevent them. The answer to the latter issue	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
U8	is the installation of cooling towers and containment domes at	Safety alternatives	Section 4.4.1
U9	all reactor sites at SRP and mechanisms supplied for recycling discharge waters.	Alternative cooling	Section 4.4.2, Appendix I See Comment E6
	The EIS now in progress, truncated though it may be, should address itself to this question. And the injunction we will seek in a hearing scheduled for Washington, August 16th, will stop the process at L-Reactor and assure a more meaningful EIS.		

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
U10	More importantly, it will give pause to determine by what scale of risk do we measure the values of a healthy and stable environment versus expediency and cost effectiveness.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix G

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF KEN MATTHEWS			
	I'm Ken Matthews, a member of Natural Resources and Energy Management Committee of the Savannah Area Chamber of Commerce. I'm speaking on behalf of our organization. I want to thank you for this opportunity to present our point of view on the scope of the Environmental Impact Statement relative to the proposed restart of the L-Reactor. I might mention that the Savannah Chamber of Commerce is a business organization founded in 1803 that represents 1400 businesses in the community. Our primary emphasis is on economic development with additional concern for the quality of life that makes Savannah an attractive environment for our current residents as well as an incentive for attracting new business and industry to this area. The Chamber, as expressed previously, has grave concerns over the Department of Energy's plans for reactivation and expansion of facilities at the Savannah River Plant. Since our community is 88 miles downriver and downwind from the Savannah River Plant, we fear that our air and water quality may be adversely affected by the L-Reactor restart. Consequently, we believe that the Environmental Impact Statement should take into account the cumulative effects of the present and proposed facilities at the Savannah River Plant as well as those of contiguous operations, such as Georgia Power Company's Plant Vogtle and the Allied General Nuclear Processing Facility in Barnwell, South Carolina.		
V1	The Chamber, as expressed previously, has grave concerns over the Department of Energy's plans for reactivation and expansion of facilities at the Savannah River Plant. Since our community is 88 miles downriver and downwind from the Savannah River Plant, we fear that our air and water quality may be adversely affected by the L-Reactor restart. Consequently, we believe that the Environmental Impact Statement should take into account the cumulative effects of the present and proposed facilities at the Savannah River Plant as well as those of contiguous operations, such as Georgia Power Company's Plant Vogtle and the Allied General Nuclear Processing Facility in Barnwell, South Carolina.	Atmospheric effects	Sections 4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, Appendix B
V2		Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2, Appendix D
V3		SRP and regional effects	Section 5.2.6
V4	The Chamber also opposes any additional plant expansions until such time as more effective control of radioactive substances has been demonstrated for the existing facilities. We have a further concern that there is a double standard applied to those projects of the Department of Energy as opposed to those carried out by the private sector. Our concern is that the Department of Energy's standards are not comparable to those of the Nuclear Regulatory Commission, nor are they subject to the independent review of that agency.	Cumulative radiological effects	Sections 3.7.1, 5.1.2, 5.2.6
V5		Regulatory requirements	Sections 7.1, 7.2

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
V6	The Chamber has consistently expressed its concern for protection of the aquifer which is recharged near the Savannah River Plant. Quality groundwater is an extremely important natural resource to Savannah and must be protected.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F See Comment B6
V7	As the Savannah area's groundwater supply becomes more scarce through increased demand, we believe that the community will be forced to rely to a much greater extent on the resources of the Savannah River for potable drinking water and for industrial use.	Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2, Appendix D
V8	The Environmental Impact Statement should address these health and public safety concerns that could affect our community's ability to grow and prosper. We thank the Department of Energy for this opportunity to present our views to be considered in the scope of the Environmental Impact Statement, which we request address objectively our concerns for groundwater and river water contamination, cumulative effects of multiple radiological facilities in the area of the Savannah River, and thirdly, the L-Reactor components that are inconsistent with commercial facilities.	Socioeconomic effects	Sections 4.1.1.1, 4.2.1.5, 5.1.1.1, 5.2.1

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF JOEL REED			
	I'm Joel Reed, and I don't have any affiliation. I just have three specific suggestions on use of information and data which will go into the EIS.		
W1	It's my understanding that the calculations for the maximum permissible amount of atmospheric emissions is based on an even distribution throughout the circumference area.	Atmospheric effects	Sections 4.1.1.6, 4.1.2.1, 4.2.2.1, 4.3.1, 5.1.1.3, 5.1.2.2, Appendix B
	I would like to remind the Department they need to consider the wind factor, which will reach an uneven build-up in certain areas downwind from the plant.		
W2	This also applies for the calculations for the water emissions, the waste in the water. I believe it's Cesium-137.	Radiocesium remobilization	Sections 3.7.2, 4.1.2.4, Appendix B, Appendix D
	You can assume that there is going to be an uneven distribution by current and wind. All this is going to affect and lead to an increased build-up in one area and no build-up in another area.		
W3	And the third suggestion is to consider the bioaccumulation of the waste in the food chain of the environment. The wastes that are emitted by the reactor in both atmosphere and water are going to be absorbed into the ecological food chain at each level. That means each organism, plant, fish, birds and humans, will be subjected to an increased build-up of waste, so you can't just look at one level in that chain. You have to consider the effects in each level of the chain.	Radiological effects	Sections 5.1.2, 5.2.6, Appendix B

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF VIRGINIA BROWN			
	I had thought I was going to precede two other speakers, so the timing on some of my verbs isn't quite right.		
X1	To the United States Department of Energy: I am Virginia Brown here today representing the League of Women Voters of Savannah-Chatham. The local League has, over the past several months, worked closely with other Leagues of Women Voters which have involved themselves in the primary issues of environmental protection in connection with the start-up of the L-Reactor at the Savannah River Plant. We have joined forces also with other groups and individuals in some of their concerns about this issue and the other issues about environmental impact of the entire Savannah River Plant operation. The League of Women Voters has, from its beginning, concerned itself with taking action "in the public interest on government measures and policy." This is from a 1923 statement of purpose and policy of the League of Women Voters of the United States. In the issue under discussion today regarding the Environmental Impact Statement on the L-Reactor, the League is gratified that our sought-after action to provide such an EIS is being implemented in accordance with requirements under the National Environmental Policy Act of 1969. The latter government policy measure was actively supported by the League of Women Voters of the United States from its inception. Since then, the League has constantly monitored those activities which come under NEPA's regulatory requirements. This week, our concerns about the Savannah River Plant have already been addressed by the League of Women Voters of South Carolina. We concur in the statement about needs made by the representatives of the South Carolina League. Today, the Savannah-Chatham League of Women Voters is here to say we fully support statements about the Environmental Impact Statement regarding the L-Reactor and the impacts at the Savannah River Plant to be made by the League of Women Voters of	SRP and regional effects	Section 5.2

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
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Georgia, represented by Ms. Geraldine LeMay and by Georgia Conservancy and Coastal Citizens for Clean Environment representative Larry Benedict.

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF MELISSA ALLEN HEATH			
	My name is Melissa Allen Heath. I just represent myself. I'm a law student at the University of Georgia and will be co-chairman of the Environmental Law Association there this year.		
	I echo all the concerns that have been voiced today. I have just a few things to add.		
	One, I would like to formally register an observation that this hearing has not been widely publicized. It took me over an hour on the telephone yesterday to find out where it was, and the DOE telephone numbers in Atlanta are, as listed in the Atlanta information, now the Department of Labor.		
K-64 Y1	I made several long-distance phone calls before I found this all out. My only other specific observation is the effect on a thousand acres of marshland through Steel Creek and possibly more each year should be measured not only in the effect on endangered species, but also the effect on all species and the effect on the ecosystem in general, not only through bioaccumulation and the effects on the river, but also just on the impact that will have on the ecosystem and on fisheries, which is a valuable resource in Georgia.	Wetland impacts	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
Y2		Endangered species	Sections 3.6.1.4, 3.6.2.3, 4.1.1.4, Appendix C
Y3		Radiological effects	Sections 5.1.2, 5.2.6, Appendix B
Y4		Fisheries	Sections 5.2.4.2, 5.2.5.1, Appendix C
Y5	Other than that, I think it's very important to consider the inclusion of a containment dome, cooling towers, recycling system and that the groundwater effects are an increased concern to everyone that I have talked to the last few days in Savannah.	Safety alternatives	Section 4.4.1
Y6		Alternative cooling	Section 4.4.2, Appendix I, See Comment E6
Y7		Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F See Comment B6

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF ELWIN E. TILSON			
	My name is Elwin Tilson, and I am representing myself at this meeting. I am an assistant professor of radiation science; although I have numerous concerns that I would like the EIS to address, I feel that most of those have been addressed by other people in other areas. However, there is one area of extreme concern that I have in the preparation of the EIS, and that is in the rigor, the scientific rigor of the documents used to derive decisions used both in the Environmental Assessment, and I assume also being used in the development of the EIS.		
Z1	My professional opinion is that there are numerous cases in documents where there is insufficient scientific rigor, and there are assumptions that seriously affect the outcome of the study but are not adequately supported nor researched. There are three examples I would just like to bring to the attention of the hearing as general examples. This process has happened in numerous documents that I have reviewed.	NEPA procedures	Foreword
Z2	The first is the method used to calculate the radiation doses in both airborne and waterborne contamination from radioisotopes. It has one basic assumption in it that makes the calculation method inappropriate, and the calculation is based on the assumption of uniform distribution of radionuclides in the air for airborne releases or in the water for waterborne releases. Unfortunately, the way that these releases do operate, in reality, is not so that the release is uniformly distributed throughout a given volume of air or water. What happens is that the radiation is concentrated in areas and does tend to be -- it is very concentrated in some areas and unconcentrated in other areas. Many of the documents that have been used in the past make the assumption that there is uniform dilution of radionuclides in both airborne and waterborne types of situations, a major flaw in methodology.	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix D

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
Z3	Another major flaw in methodology I have identified in the Environmental Assessment is the local lack of consideration of an effect called bioaccumulation. Bioaccumulation means just that plants and animals absorb radionuclides and will accumulate a higher level of radiation than the environment. They are in return eaten by higher organisms, and it accumulates further and further up the food chain. In many of the documents, it is totally ignored, and it is a major consequence from low level radiation release over periods of time.	Radiological effects	Appendix B
Z4	A third incidence of false assumptions when making conclusions is related to the containment system used at the L-Reactor. In the Environmental Assessment, the statement was made that regardless of what the accident is, and one of the examples that they use was if they had a loss of coolant accident, that they have a filter system that is capable of removing virtually all or all of the airborne radionuclides. However, the one assumption they made there which is a false assumption is that the filters that are used in the containment system are equally effective when wet from steam, and in actuality, DOE documents do indicate that this particular filter system is not functional when it becomes water-saturated which, unfortunately, is exactly the situation that would happen with a loss of coolant accident.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G
Z5	There are many other types of examples that I could bring to the hearing, but my major concern is that in the preparation of the EIS, that the basic assumptions used behind the technical documents that are being used be reexamined and reassessed because, as I stated before, in my professional opinion, there are numerous false assumptions used to make decisions in documents.	NEPA procedures	Foreword

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
STATEMENT OF JOHN MACLEAN			
	My name is John Maclean. I represent a very informal group of about a half dozen people. We have basically two concerns that we would like the EIS to address, some of which you have pointed out in your presentation.		
AA1	The first concern is that the L-Reactor and the requirements for the L-Reactor, there seems to be a double standard that may be applied to the L-Reactor versus a private group. For example, the NRC regulations for a private or utility-based power plant would be lot stricter, it seems, than the standards that are to be applied for the L-Reactor. It would seem or would appear to seem that if the NRC is going to require a private utility plant to have various things, like a containment dome, a cooling tower, it would seem to make even more sense to have those same specifications, the same requirements for a plant that produces plutonium material for nuclear weapons. I think the double standard question should be addressed in the EIS.	Regulatory requirement	Chapter 7
AA2	The second concern is very similar and that is that the EIS should at least spend some time in addressing the same scenario that Babcock & Wilcox faced, Three Mile Island. For example, would the L-Reactor actually survive the scenario of a locked overflow valve, the subsequent misreading of temperature by the instruments, the subsequent cutting off of the coolant pumps, the subsequent melting of the zirconium around the reactor core and the subsequent creation of a bubble underneath. At least Three Mile Island had a containment dome. Could the L-Reactor survive that same scenario? Granted it's a worst case scenario, but it did happen.	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G

Table K-3. Scoping statements and EIS sections or DOE's responses (continued)

Comment number	Statement	Scoping topic	EIS section or DOE comment
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The EIS should address whether or not the L-Reactor could survive that and should also address whether or not the NRC requirements should be applied to the L-Reactor.

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Table K-5. Scoping letters and EIS sections or DOE's responses

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF ROGER L. BANKS		
	UNITED STATES DEPARTMENT OF THE INTERIOR Fish and Wildlife Service P.O. Box 12559 217 Fort Johnson Road Charleston, South Carolina 29412		
	July 27, 1983		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operations Office P.O. Box A Aiken, South Carolina 29801		
	Re: Scoping comments - EIS for L-Reactor		
	Dear Mr. Sires:		
	The U.S. Fish and Wildlife Service offers the following comments and suggestions for consideration in connection with preparation of the above referenced EIS. The Service has previously reviewed, and is generally familiar with, the content of the Environmental Assessment (EA) prepared for L-Reactor start-up. Within the confines of addressing existing fish and wildlife resources, and impacts to these resources arising from thermal effluents from L-Reactor, the EA represents a substantial base from which to build the fish and wildlife portions of the EIS.		
	The Service suggests the following additional informational needs and issues be addressed within the scope of a thorough impact analysis:		
AB1	1. The preliminary list of issues presented in DOE's	Wetland impacts	Sections 4.1.1.4, 5.1.1.2, 5.2.4, Appendix C, Appendix I

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AB2	July 19, 1983 information release should be expanded	Wildlife	Sections 3.6.1, 3.6.2, 4.1.1, 4.4.2, Appendix C, Appendix I
AB3	to include the major topics of wetlands, wildlife and surface water quality.	Surface water quality	Section 4.1.1.5.
AB4	2. Qualification and quantification of available fisheries spawning and nursery habitat in the Steel Creek floodplain as it would be affected by L-Reactor start-up.	Fisheries	Sections 3.6.2, 5.2.5, Appendix C
AB5	3. Use of existing conditions in Steel Creek and its floodplain should be used as a baseline from which to determine start-up impacts rather than utilizing pre-1968 conditions.	NEPA procedures	Sections 3.4.1.2, 4.1.1, 4.1.2.2
AB6	4. Impact analysis should concentrate on habitat and resource losses as finite units rather than relating these losses as percentages of remaining unaffected similar habitats and resources at the Savannah River Plant (SRP) or within the whole Savannah River basin.	Wetlands impacts	Sections 4.1.1.4, 4.4.2, 5.2.4, Appendix C, Appendix I
AB7	5. Cumulative wetland habitat losses from all SRP operations should be discussed.	Thermal effects	Sections 4.1.1.4, 4.4.2, 4.4.3.4, 5.2.4, 5.2.5.1
AB8	6. Since the Steel Creek system is in an early successional stage of recovery from pre-1968 operational impacts, and since the fish and wildlife resource values of a system may vary with its successional state, a thorough discussion of future successional seres and values without the project should be included.	Wetlands impacts	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
AB9	7. Adverse impacts on recreational fishing in the vicinity of the Steel Creek/Savannah River confluence should be addressed. Fisheries biologists with the South Carolina Wildlife and Marine Resources Department have reported that this is the most popular shad fishing spot in the State of South Carolina, and the most popular fishing spot for largemouth bass and red-breast in the Savannah River.	Fisheries	Sections 5.2.4.2, 5.2.5.1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AB10	8. The EIS should include a thorough discussion of current water quality standards as regulated by the South Carolina Department of Health and Environmental Control, and how the L-Reactor discharge would comply with these standards.	Regulatory requirements	Chapter 7
AB11	9. A thorough exploration of non-destructive cooling water alternatives such as cooling towers and/or cooling ponds should be incorporated with the EIS. Cooling pond alternatives should not be limited to damming segments of Steel Creek, but should also include the feasibility of digging lakes or ponds out of available uplands at SRP. Scheduling and/or financial concerns should not preclude thorough exploration of these cooling water alternatives.	Alternative cooling	Sections 4.4.2, Appendix I See Comment E6

The Service appreciates this opportunity for input into the EIS process at this early stage.

Sincerely yours,

Roger L. Banks
Field Supervisor

RLB/SG/lm

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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LETTER OF ARTHUR H. DEXTER

Rt. 1 Box 80A
Aiken, S.C. 29801
August 3, 1983

Mr. M. J. Sires, III
Assistant Manager for Health,
Safety and Environment
U.S. Dept. of Energy
Savannah River Operations Office
P.O. Box A
Aiken, S.C. 29801

Dear Mr. Sires:

My name is Arthur H. Dexter and I am a retired employee of the E. I. du Pont de Nemours and Co. After graduation from Rensselaer Polytechnic Institute with an M.S. degree in physics in 1951, I was assigned by du Pont to the Argonne National Laboratory where I led a small group of physicists in performing exponential experiments, with the CP-2 reactor at Palos Park, that determined the basic lattice parameters for the SRP reactors. In 1953, I was transferred to the Savannah River Plant and from then until retirement in 1981, I performed research, development, and safety studies that covered or touched on almost every aspect of the plant's processes from reactor monitoring and safety systems to separations processes and weapons development. During this period I served in the following Savannah River Laboratory divisions: Instrument Development, Applied Physics, Experimental Physics, Theoretical Physics, Nuclear Materials, Reactor Engineering, Environmental Transport, and Actinide Technology. As a result of these many assignments, I have an extensive overall knowledge of the SRP.

I am writing in reply to DOE's invitation of July 19, 1983 that invited members of the general public, like myself, to submit comments and suggestions for consideration in connection with the preparation of the Environmental Impact Statement (EIS) for the 105-L reactor. I remain as concerned about the safety of residents in the surrounding communities as I did as an SRP employee and I should like to feel that the EIS you will generate

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AC1	is honest, factual, and presents an up-to-date evaluation of the risks to which the populace is subject. I am concerned in particular that the subject of confinement/containment, which after all is the most important concern of any operating reactor, should be treated accurately and openly. Perhaps it seems strange that I should expect anything other than this, but I am concerned that a recent publication that I read failed to do this. I refer to a handout distributed at the public hearings of 5/24/83 at the H. O. Weeks Center, Aiken, and which was entitled "Confinement vs. Containment" (no authorship given). This publication not only failed to give a factual presentation of the existing confinement/containment situation at SRP but actually created some impressions that just were not true. I subsequently obtained a copy of the Environmental Assessment and searched it for the basic information on confinement/containment that I expected to find, but to no avail. I am concerned that if this state of affairs carries over to the EIS, then that document will merely give lip service to safety without ever examining the actual risks to which the public is subject. Certainly DOE, du Pont, and the rest of us do not want this to occur. For this reason, I wish to present in simplified form the essential information that I believe the EIS must contain for accuracy. I will do this in three sections that present: A. the scenario that applies in the case of a loss of coolant accident (LOCA) with associated melting of the fuel, B. the role of the SRP confinement system in this scenario, and C. a summary that includes some personal comments that I feel relevant.	Safety alternatives	Section 4.4.1, Appendix G
AC2	A. <u>The Loss of Coolant Accident (LOCA)/Fuel Melt Down Scenario</u>	Accident analysis	Sections 4.2.1, 4.4.1, Appendix G.
AC3	In the event of a LOCA with an associated melting of reactor fuel, existing contingency plans at SRP call for flooding of the fuel core with water from the Savannah River, in order to provide emergency cooling of the fuel. Initial admission rates would be on the order of 1500 gallons per minute, as I recall. This emergency cooling water almost immediately overflows the 105-L reactor building and flows through: 1) the 106-"building" (a 50,000 gallon basin), and 2) a 500,000 gallon tank, exiting finally into an outdoor excavation that has a capacity of 50 million gallons. Since it is projected that cooling water will probably have to be provided for several weeks, the earthen	Accident analysis	Sections 4.2.1.5, Appendix G

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	basin will be substantially filled by the end of this time. (At the initial rate of 1500 gallons per minute, 23 days would be required to fill the basin, but the initial flow would be reduced with time.)		
AC4	The major portion of the overall radioactivity released from the fuel will be transported by the emergency cooling water to the outdoor earthen basin where the radioactive noble gases and radioactive iodine (radioiodine) will diffuse from the basin water surface to the atmosphere. Studies that I have performed at SRP and reported upon at a Sun Valley, Idaho, "Air Cleaning Conference," indicate that there will be essentially a quantitative (100%) release of the radioiodine to the atmosphere. Those of us who have been involved with this scenario envision a "purple cloud" of iodine emanating from the basin and being transported by the dictates of the wind.	Accident analysis	Sections 4.2.1.1, 4.2.1.4, Appendix G
AC5	Only a small portion of the radioactivity released by the molten fuel is subject to retention in the 105-L reactor building: (1) the noble gases and radioiodine released directly to the building atmosphere and (2) noble gases and radioiodine that are released within the 500,000 gallon tank, as it fills with water, and which are piped back to the 105-L reactor building. The contribution from (2) will be terminated by the filling of the tank, which will require about five hours. The airborne radioactivity in the 105-L building will be carried by the building ventilation system to a series of demisters, high-efficiency particulate air filters (HEPA filters) and carbon absorption beds, which, in SRP parlance, is referred to as the confinement system. <u>B. The Confinement System</u> The Confinement System is intended to remove: (1) radioactive aerosol particulates by means of the HEPA filters and (2) radioiodine by means of the carbon absorption beds. The radioactive noble gases are not affected by the confinement system and pass to the atmosphere through the 200 ft. stack of the 105-L reactor building.	Accident analysis	Sections 4.2.1.3, 4.2.1.4, Appendix G
AC6	Since there has never been an accident at SRP of the kind described in the Scenario of Section A, it cannot be said with certainty that the confinement system will function as	Accident analysis	Section 4.2.1.4, Appendix G

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	intended. However, even if it performs as designed it will serve only to remove a small portion of the total radioactivity released from the fuel since the majority will have passed to the 50-million gallon basin. However, there are several scenarios which have been advanced that may serve to partially, or even totally, negate the effectiveness of the confinement system: - There is an ever present danger of a steam or hydrogen explosion accompanying the melt down accident. This could result in the generation of overpressures that could destroy the paper-like HEPA filters, particularly if there is steam wetting of the HEPA's, which would cause a loss in the inherent strength of the filter paper. Additionally, an explosion of this kind could cause the carbon beds to be coated with moisture which would render them ineffective for the removal of iodine. This could result in the release of essentially all airborne radioactivity to the outside environment via the 200 ft. stack. - A second and equally serious failure of the confinement system can occur if there is an overloading of the carbon beds with sufficient radioactivity to cause self-heating, ignition, and fire in the charcoal material. This in turn could result in the release of all the previously absorbed radioiodine via the 200 ft. stack. The propensity of carbon for ignition is abetted by the reduction in ignition temperature that occurs in carbon as a result of aging.		
AC7	Still another cause for failure of the carbon beds to function as intended is the inability of the carbon beds to absorb radioiodine when the radioiodine is in the form of an organic iodide compound. There is considerable experimental evidence to indicate that a very large portion of the radioiodine released by the molten fuel may be instantaneously converted to organic compounds in the course of a fuel meltdown. This radioiodine would not be absorbed by the carbon beds and would pass up the stack.	Accident analysis	Section 4.2.1.4, Appendix C

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	<u>C. Summary</u>		
AC8	The major portion of the radioactivity released in a LOCA/fuel meltdown accident will pass to the excavated, 50-million gallon basin from which radioactive noble gases and radioiodine will diffuse to the atmosphere and will be carried off by the wind. A smaller portion of the airborne radioactivity in the reactor building may be retained by the SRP confinement system but there is a reasonable possibility that it may not be retained. Finally, I wish to offer a few personal comments and observations as regards the EIS: While the message contained in the summary is not one that will instill confidence in those who reside near the plant, it is factual and honest in its essentials. A candid EIS should provide an overdue acknowledgement that the present SRP system is in reality a non-confinement system for the scenario outlined. Obviously the EIS must treat this matter and indicate how these deficiencies can be rectified. However, some nine or ten years ago I was one of several researchers who sought unsuccessfully for a means to retain the radioiodine in the 50-million gallon basin. My own studies with sodium thiosulfate proved unavailing in that the radioactivity of the basin water, it was demonstrated, would cause the release of radioiodine and negate the retention properties of the thiosulfate. I believe that we exhausted all practical mechanical and chemical possibilities at that time. In view of this, I can only conclude that the best hope for the protection of the populace and the environment lies in the retrofitting of a containment dome to the 105-L reactor. The effectiveness of such containment vessels has been amply demonstrated in the Three-Mile Island accident. Moreover, as you are probably aware, the Reactor Engineering Division of the Savannah River Laboratory has advanced proposals and designs for containment domes over a period of years. Unfortunately these proposals to have been turned down on the basis of cost. Perhaps it is time	Accident analysis	Section 4.2.1.4, Appendix G
AC9		Accident analysis	Sections 4.2.1.2, 4.4.1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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to acknowledge that the cost is a part of our doing business at SRP and not greatly different than the costs we are all willing to shoulder for the solidification of waste.

I look forward to seeing the EIS and hope that it will lay to rest my concerns by examining the confinement/containment issues with greater candor and in greater detail than was done in the Environmental Assessment.

Yours truly,

Arthur H. Dexter

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF JOHN F. DOHERTY			
318 Summit Ave. #3 Brighton, Mass. 02135			
August 3, 1983			
Mr. M. J. Sires, III Assistant Manager for Health, Safety & Environment U.S. Dept. of Energy Savannah River Operations Office P.O. Box A Aiken, S.C. 29801			
Dear Mr. Sires:			
Below are my written suggestions on the scope for the EIS for the L-Reactor Resumption of Operation, at the Savannah River Plant. I am replying to an Energy Department notice in the July 19, 1983, <u>Federal Register</u> , at Page 32966.			
AD1	1. The EIS should have a determination of the dose to a person of radioactivity at a distance of one mile, five miles and ten miles from the reactor in the event of a worst case accident.	Accident analysis	Section 4.2.1.5, Appendix G
AD2	2. The environmental consequences of a worst case accident should be analyzed in accordance with the recent <u>Sierra Club vs Sigler</u> , decision, 695 F 2d 957 (5th Cir: 1983) for both an L-reactor without a containment and one with a containment that meets the requirements of Nuclear Regulatory Commission regulations: 10 CFR 50, Appendix A, Design Criteria 50-57.	Safety alternatives	Section 4.4.1
AD3	3. A cost benefit analysis should be presented in the EIS comparing a reactor with containment with one without a containment (such as proposed in the EA, taking into	Safety alternatives	Section 4.4.1.6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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account doses to the public (iodine* and other materials)
at varying distances with consequent non-fatal and fatal
cancers, and non-fatal and fatal birth defects.

Thank you for this opportunity.

John F. Doherty

*/ Iodine is important here because a containment's primary
use is to contain gaseous iodine until it has disintegrated
to lighter elements which are not subject to rapid uptake
as iodine is to the thyroid gland.

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF E. T. HEINEN		
	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY Region IV 345 Courtland Street Atlanta, Georgia 30365		
	4 PM-EA/JM		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operations Office P.O. Box A Aiken, South Carolina 29801		
	Dear Mr. Sires:		
	On August 1 and 2, a member of my staff participated in a series of scoping meetings on the EIS the proposed resumption of the L-Reactor operation at the Savannah River Plant (SRP) in Aiken, South Carolina. Based upon these meetings and our review of the <u>Federal Register</u> notice for the initiation of the EIS scoping process, we believe that the Department of Energy (DOE) has identified the majority of the issues and analyses that need to be developed through the NEPA process. However, to ensure that our concerns are adequately addressed, we offer the following issues we believe need special attention in the EIS.		
AE1	First, we believe that all of the thermal mitigation alternatives for the heated water discharges from the L-Reactor need to be fully discussed in the EIS. Such a discussion should include the direct environmental impacts for each of the alternatives, estimated cost of implementing each alternative, and the relationship of each thermal mitigation alternative to the ongoing thermal mitigation study at SRP.	Alternative cooling	Section 4.4.2, Appendix I See Comment E6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AE2	Second, to assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in the receiving stream, Section 316(a) of the Clean Water Act requires DOE to demonstrate that the plant's thermal discharge would not impact existing stream conditions. The EIS should provide the information needed to complete this analysis.	Fisheries	Sections 5.2.4.2, 5.2.5.1, Appendix C, Appendix I
AE3	Third, the South Carolina Department of Health and Environmental Control (SCDHEC) has drafted an NPDES permit for the L-Reactor that requires the effluent from the plant to comply with thermal stream criteria at the point of discharge into Steel Creek, rather than at the edge of a rather extensive mixing zone in the Savannah River (as specified in the current NPDES permit). Consistent with this position, the EIS should discuss the effects of thermal discharge in the context of the direct and indirect effects on Steel Creek and its floodplain. In this regard, the EIS should also discuss the administrative procedures which DOE will utilize should the Draft NPDES permit be issued limiting thermal discharges into Steel Creek.	Regulatory requirements	Chapter 7
AE4		Thermal effects	Sections 4.1.1.4, 4.4.2, 4.4.3.4, 5.1.1.2, 5.2.4, 5.2.5.1
AE5	Fourth, to aid the general public in understanding the offsite radiation doses from the L-Reactor, the offsite dose levels should be compared to normal background levels. Also, the health effects from the offsite exposure should be discussed in context with DOE's ongoing long term epidemiological study at SRP.	Radiological effects	Sections 5.1.2, 5.2.6, Appendix B, Appendix D
AE6		Health effects	Sections 5.1.2.5, 5.2.7, Appendix B
AE7	Finally, the EIS should develop alternatives for the waste discharges from the operation of the L-Reactor to the seepage basins at the chemical separation areas (F-area, H-area, M-area, Fuel and Target Fabrication areas). These alternatives should be consistent with Parts 261-264 of the Resource Recovery and Conservation Act (RCRA).	Seepage basins	Section 4.4.3
AE8		Regulatory requirements	Chapter 7

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	We appreciate the opportunity to comment on the proposed scope of the EIS and provide input into the planning for this important project. Members of my staff will be happy to discuss the specifics of any of the issues raised above. Sincerely yours, E. T. Heinen, Chief Environmental Assessment Branch Office of Policy & Management		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF ERNEST F. HOLLINGS			
	UNITED STATES SENATE 115 Senate Office Building Washington, D.C. 20510 202-224-6121		
	ERNEST F. HOLLINGS South Carolina	Committees: BUDGET: Ranking Democrat	
	Offices: 1835 Assembly Street Columbia, South Carolina 29201 803-765-5731	APPROPRIATIONS State, Justice, Commerce and the Judiciary: Ranking Democratic	
	103 Federal Building Spartanburg, South Carolina 29301 803-585-3702	Defense Labor, Health and Human Services, Education Energy and Water Development Legislative	
	242 Federal Building Greenville, South Carolina 29603 803-233-5366	COMMERCE, SCIENCE, AND TRANSPORTATION Communications: Ranking Democrat	
	112 Custom House 200 East Bay Street Charleston, South Carolina 29401 803-724-4525	Surface Transportation Science, Technology, and Space	
	233 Federal Building Florence, South Carolina 29503 803-662-8135	DEMOCRATIC POLICY COMMITTEE OFFICE OF TECHNOLOGY ASSESSMENT NATIONAL OCEAN POLICY STUDY	

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
August 3, 1983	Mr. Richard P. Denise, Acting Manager Department of Energy Savannah River Operations Office Box A Aiken, S.C. 29801		
	Dear Mr. Denise:		
	Thank you for your recent letter inviting my comments on the scope of the L-Reactor EIS. I appreciate you writing.		
	Since my position on the EIS issue is well-known, there seems no point in submitting a statement for this week's hearings. I simply enclose a portion of my July 10 statement on the Senate floor, in which I listed the topics which I feel the EIS should cover.		
	I am glad to see the EIS finally underway. If it fully answers the questions that have been raised, and if it presents the advantages and disadvantages of the different mitigation options, then it will do much to lay the present dispute to rest.		
	Thank you again for writing.		
	Sincerely,		
	Ernest F. Hollings		
	Enclosure		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	CONGRESSIONAL RECORD--SENATE Excerpts from Senator Hollings' June 10 floor statement on the L-Reactor EIS June 10, 1983 Finally, Mr. President, I want to emphasize again that this environment impact statement is to be a serious effort, and one that fully addresses the questions that have been raised by me, Senator MATTINGLY, and many others. Attached to this statement is a list of the topics that I want to see addressed in the EIS, and I ask that it be printed at the conclusion of these remarks. Mr. President, I understand that the distinguished chairman of the Armed Services Committee, Senator TOWER, agrees with me on this point. Mr. TOWER. Mr. President, I do agree with the Senator from South Carolina that this EIS should be a serious study and one that addresses the environmental questions that have been raised about the L-reactor project. I have seen the list of topics that the Senator wants the EIS to address, and I feel that this list is reasonable. My concern has been to keep this EIS from taking so long that it hurts vital national security programs, but this expedited schedule ensures that the EIS will be completed in a timely way. It also provides the Department of Energy with sufficient time to perform a complete, indepth analysis of the issues raised. Mr. HOLLINGS. I thank the Senator from Texas, and once again want to commend him, Senator JACKSON, and Senator MATTINGLY for their roles in this matter. The material requested to be printed in the Record is as follows: Topics That The L-Reactor EIS Should Cover in Detail		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	Since the purpose of the L-Reactor EIS is to provide additional information to the public and to elected officials, and to allow for additional citizen input, the EIS should provide details on those issues that have been raised by citizens and government officials. In particular, the EIS should provide clear, complete information on the following topics.		
AF1	(1) Groundwater contamination.--Since the L-Reactor will lead to more fuel fabrication in the "M" area of the Savannah River Plant, one question that arises is whether restarting the L-Reactor will add to the already troubling groundwater contamination problems in M. There is also the question of whether L/Reactor-related activities in the separations area will, or possibly can, lead to groundwater contamination. Thus the EIS should discuss these matters in considerable detail, especially covering these points:	Groundwater contamination	Sections 4.1.2.2, Appendix F
AF2	(a) Potential impacts.--In particular, what quantities of chemicals and radioactive materials have already been discharged into the ground at both M-area and the separations area? What steps are being taken now to prevent further contamination in these areas, to monitor existing contamination, and to clean up those underground reservoirs now contaminated? In particular, what will be done to clean up or restore the Congaree and Tuscaloosa aquifers? How much would the L-Reactor's operation, using current pollution control equipment, add to the present discharges? And what are the pathways by which any such contamination could flow into areas outside of the Savannah River Plant?	Groundwater contamination	Section 4.1.2.2, Appendix F
AF3		Monitoring	Sections 6.1.1, 6.2.2
AF4	(b) Mitigation options.--It is very important that the EIS discuss in detail the options available--both in the short-term and the longer-term--to prevent or mitigate any groundwater contamination that might be caused by L or L-related activities. For instance, commercial plants of all kinds often use advanced waste water treatment technologies? Which are available here, at what costs, and with what time frames?	Mitigation measures	Section 4.4.3
	(2) Radiocesium and tritium:		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AF5	(a) Potential impacts.--There are a great many questions about the cesium now in the Steel Creek area that will be resuspended by L-Reactor operations. Among the questions that the EIS should explicitly address and answer are the following. How much cesium is in the Creek area, where exactly is it, and how did it get there? Where exactly is it likely to be deposited after the restart and at what pH? What concentrations are likely at different locations along the Creek and the Savannah River? What are the possible health effects of radiocesium? What data and assumptions lie behind DOE's answers to these questions? Similar details on waterborne and airborne tritium releases also should be provided.	Radiocesium remobilization	Sections 3.7.2, 4.1.2.4, Appendix B, Appendix D
AF6 AF7		Health effects Radiological effects	Section 4.1.2.4 Sections 5.1.2, 5.2.6, Appendix B, Appendix D
AF8	(b) Mitigation options.--Would cooling towers or other cooling	Alternative cooling	Section 4.4.2, Appendix I, Comment E6
AF9	technologies reduce the resuspension or migration of the radio-cesium in Steel Creek? It is possible to excavate the sedi-ments presently holding the cesium? What technologies are available for retrieving and storing the cesium if it should end up in any city's water treatment filters or sludge?	Radiocesium remobilization	Section 4.1.2.4, Appendix B
AF10	Similarly, what, if anything, can be done to reduce tritium emissions from either the L-Reactor or L-related activities?	Mitigation measures	Sections 4.4.3.4, 4.4.5
	(3) Thermal effects.--Present DOE plans call for the direct discharge of the L-Reactor's cooling water into Steel Creek. This leads to several questions.		
AF11	(a) Potential impacts.--How would both the heat and flooding	Thermal effects	Sections 4.1.1.4, 4.4.2, 4.4.3.4, 5.1.1.2, 5.2.4, 5.2.5.1
AF12	caused by direct discharge affect both neighboring wetlands and animal life? What data and assumptions lie behind these calculations?	Wetlands effects	Sections 4.1.1.4, 4.4.2, 5.1.1.2, Appendix C, Appendix I
AF13	(b) Mitigation options.--The EIS should contain detailed information on the options available to manage this cooling water. Both interim measures, such as spray cooling, and longer-term options, such as cooling towers, should be dis-cussed. Details should be presented on cost, efficacy, and the time required to install.	Alternative cooling	Section 4.4.2, Appendix I See Comment E6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AF14	(4) Containment.--The reactors at the Savannah River Plant do not have containment domes of the type required at commercial nuclear power plants. The EIS should present a clear description of why this is the case, what technologies are now used to prevent accidental releases of nuclear material, and how much a containment dome for the L-Reactor might cost in terms of time and money.	Safety alternatives	Section 4.4.1, Appendix G

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF JOHN MACLEAN, LARRY SPRAGUE, MARY ELLEN SPRAGUE, CAROLYN ROCKWOOD, FERRIS CANN III, AND FRANCES MACLEAN,		
	August 8, 1983		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety & Environment U.S. Department of Energy Savannah River Operations Office Post Office Box A Aiken, South Carolina 29801		
	Attention: EIS Scope		
	Dear Mr. Sires:		
	Please include the following comments in your Scope Review hearing testimony:		
AG1	1. The EIS should address the degree of urgency and necessity for the production of plutonium by the L-Reactor. In 1980 there were 200 MX missiles proposed which have been cut back to 100 and to the present 27. The need for the new plutonium should be addressed as the code words "urgency" and "national security" should not be allowed to override the concern for safety of the public.	Need	Section 1.1
AG2	2. The EIS should address the number of jobs and the amount of	Alternative cooling	Section 4.4.2, Appendix I
AG3	money that will be pumped into the economy by construction of a cooling tower and a containment dome over the L-Reactor.	Safety alternative	Comment E6 Section 4.4.1, 4.4.2
AG4	3. The EIS should address the permanent disposal of 27 million gallons of high level waste which presently exists at the Savannah River Plant or at least address the permanent disposal of high level wastes which would be produced by the L-Reactor.	Radioactive waste	Section 4.1.2.8, 5.1.2.8

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AG5	4. The EIS should address why the L-Reactor is considered an old facility and not a new facility for NRC requirement purposes in view of the fact that \$215,000,000.00 will be spent on the facility.	Regulatory requirements	Chapter 7
AG6	5. The EIS should address why the NRC does not inspect the L-Reactor as it does all other commercial nuclear reactors but instead the DOE inspects the facility which it runs. It would appear to be a conflict of interest.	Regulatory requirements	Chapter 7
AG7	6. The EIS should address the effect the L-Reactor may have on an increase in cancer rates in Chatham County, Georgia, which are already highest in the state of Georgia, and also the effect the L-Reactor will have on the cancer rate in South Carolina which is three times the national average.	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B, Appendix G
AG8	7. The EIS should compare the technical and safety requirements for the Vogtle reactor which is across the river from the Savannah River Plant with technical and safety requirements of the L-Reactor.	Regulatory requirements	Chapter 7
AG9	8. The EIS should address whether the L-Reactor has the same vapor trap problem that existed at Three-Mile-Island.	Accident analysis	Section 4.2.1, Appendix G Production reactors are different from pressurized water reactors and this is not a credible scenario for the L-Reactor.
AG10	9. The EIS should address the ability or lack of ability to recycle existing plutonium in existing obsolete bombs presently stockpiled.	Need	Section 1.1

Sincerely yours,

John Maclean
Larry Sprague
Mary Ellen Sprague
Carolyn Rockwood
Ferris Cann III
Frances Maclean

cc: Senator Mack Mattingly

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF WILLIAM McLAUGHLIN			
	403 Tattnall Street Savannah, Georgia 31401 August 10, 1983		
	Mr. M. J. Sires Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operation Office P.O. Box A Aiken, S.C. 29801		
	Dear Mr. Sires:		
	I would like to request that this letter, and the questions that it addresses, be included in the scoping process on the Environmental Impact Statement for the L-Reactor at the Savannah River Plant.		
	The following are areas of grave concern to me as an environmentally concerned resident of Savannah.		
AH1	Charles R. Jeter, a regional administrator for the Environmental Protection Agency in Atlanta, stated in his testimony before the Armed Services Committee Hearing in North Augusta, South Carolina on February 9, 1983, the EPA's position on the restart and operation of the L-Reactor. Mr. Jeter stated that, "SRP plant officials agree to conduct a comprehensive hydrogeological investigation of the site." I would like to request that this be done as part of the L-Reactor's EIS.	Groundwater contamination	Appendix F
AH2	He also states that, "SRP is in the process of conducting an extensive evaluation of the M-Area to determine if remedial measures are necessary," for the protection of groundwater. I would like to request that this be done as part of the L-Reactor's EIS as an indication of potential problems of the use of seepage basins by the L-Reactor.	Groundwater contamination	Appendix F

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AH3	Mr. Jeter further states that, "Section 316(b) of the Clean Water Act requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing impacts of the aquatic system. This is accomplished through provision in the NPDES permit." I would like to request that the L-Reactor's EIS address how the NPDES permit assures the best available 1983 technology.	Fisheries	Sections 4.1.1.2, 4.4.2, 5.2.4.2, 5.2.5, Appendix C
AH4	Mr. Jeter also presents, as part of the EPA's position, that "Acting under Executive Order 11990, Protection of Wetlands, measures could be implemented by DOE to minimize or compensate for adverse impacts upon wetlands." I would like to request that the L-Reactor's EIS address just what measures have been (or will immediately be) taken to minimize the adverse impacts on wetlands as required by Executive Order 11990.	Wetlands	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
AH5	Mr. Ronald W. Cochran, representing the U.S. Department of the Interior-Fish and Wildlife Service, wrote in a letter concerning his department's review of the Environmental Assessment that "we cannot agree with a finding of no significant impact, and have major problems with several basic tenets of the document." He maintains that the Steel Creek system and associated wetlands have greatly recovered from the effects of operational discharges prior to 1968. Thus I would like to request that the L-Reactor's EIS use current 1983 Steel Creek wetlands conditions as the baseline from which to determine findings of impact, and not the misleading pre 1968 conditions.	NEPA procedures	Chapter 3, Appendix C, Appendix I
AH6	The NUS Corporation's <u>Comparisons and Evaluation of Alternative Cooling Systems for L-Reactor</u> done for the DOE ranks cooling towers as the most preferred option based on engineering and environmental criteria. I would like to request that the L-Reactor's EIS give this cooling tower recommendation option more reasonable and further consideration. In the EA this option was not considered because of the quickly upcoming projected start date. The way I understand it, this projected	Alternative cooling	Section 4.4.2 See Comment E6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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start up date is in question; and it well should be in question, when we are addressing environmental, health, and safety concerns for the citizens of South Carolina and Georgia.

Thank you, I am anxiously awaiting a response.

Sincerely,

William McLaughlin

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF JANET T. ORSELLI		
	RADIATION AWARENESS P.O. Box 81 Folly Beach, S.C. 29439		
	August 8, 1983		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operations Office P.O. Box A Aiken, South Carolina 29801		
	Dear Mr. Sires:		
	I would like to submit comments from our organization, Radiation Awareness, on the preparation of the Environmental Impact Statement (EIS) for the L-Reactor at the Savannah River Plant (SRP).		
	Radiation Awareness strives to educate the public on nuclear-related issues and provides information on ways the public can protect themselves from radiation hazards.		
AI1	We have many concerns about the environmental impacts of the L-Reactor restart and want to encourage in-depth study and use of mitigation measures by the Department of Energy (DOE), to decrease environmental damage and serious future health effects.	Mitigation measures	Sections 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5, Appendix I
	We agree that the EIS should at the minimum examine the eleven issues listed in the DOE News of July 19, 1983, and our organization would like to suggest a number of other significant factors that also need to be addressed to assure compliance with the National Environmental Policy Act (NEPA) requirements.		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AI2	Primarily, the EIS needs to provide the public and independent evaluating agencies with data concerning the levels of radiation exposure the public has received over the 25 year operation of SRP. In particular, the EIS needs to evaluate this past amount of nuclear contamination with a consideration of the additional future radioactive discharges to be released from the operation of the L-Reactor. An accounting is needed of the amount of routine or accidental releases of radiation which have occurred during each year of operation of the SRP, and then a total, cumulative radiation exposure level for members of the public during the 25 year period with an estimate of future levels of exposure from the operation of the L-Reactor. The EIS must explain and make justification for the need to increase the amount of nuclear contamination that we, the public will be forced to live with.	SRP & Regional effects	Section 5.2
AI3		Need	Section 1.1 See comment D1
AI4	It is unfortunate that most members of the public are misled and misinformed concerning the long-term health effects of repeated exposure to radiation. The DOE needs to become much more honest with the public and be willing to explain the true health consequences that can result from the long-term ingestion or inhalation of radioactively contaminated particles. It is important that this EIS not downplay the health effects or mislead the public by equating the effects of internal radiation exposure, to the less dangerous type of external radiation exposure, such as riding on airplanes or watching T.V. To regain public confidence--to say nothing of providing that which should have been made available long ago, the EIS should provide the following data:	Health effects	Sections 4.1.2.6, 5.1.2.5, 5.2.7, 6.1.4, Appendix B
	1. Accidental releases of radioactivity reported in accordance with the ERDA Manual-0502		
	2. Audits of SRP radioactive waste (from startup to present)		
	3. Releases of radioactivity at SRP (from startup to present)		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	4. "Monthly Reports" 1951-1981		
	5. Two studies done by DOE on the L-Reactor in 1972 and 1977		
	Without this vital information it would be impossible to seriously evaluate the total, cumulative health effects of the L-Reactor restart.		
AI5	Another important consideration that needs evaluation in this EIS, is the type of emergency procedures that will be taken to alert South Carolina and Georgia residents of accidental releases of radiation. To our knowledge, throughout the history of SRP operations, the public has never been notified of radiation releases in time enough to take any protective measures. This is a serious deficiency that needs to be addressed in the EIS. An outline of the steps that will be taken to warn the public of radiation exposure, definitely needs to be included.	Emergency planning	Section 4.2.1.3, Appendix H, Appendix G
AI6	In addition, the EIS should provide cost/benefit studies to examine not just on an economic basis, but more importantly on a public health basis, the long-term health benefits of purchasing equipment to reduce radiation health effects by reducing the amount of radiation routinely released.	Mitigation measures	Sections 4.4.1, 4.4.2, 4.4.3, 4.4.4, 4.4.5
AI7	The EIS should also address what future plans will be made for the permanent disposal of high-level nuclear wastes produced by the L-Reactor. Also a consideration of the resulting costs and health risks of related operations, such as transportation, decommissioning and decontamination.	Radioactive waste	See Comment S1
AI8	In conclusion, this EIS should contain a consideration of alternatives to the proposed thermal discharge temperatures (such as cooling towers or recirculation systems). Of course, ultimately there needs to be an examination of the alternative to the L-Reactor restart period. Does the need to produce more	Alternative cooling	Section 4.4.2, Appendix I See Comment E6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AI9	nuclear weapons outweigh the potential serious health effects to be suffered by South Carolina and Georgia residents? Please send me a copy of the draft EIS when available. Sincerely, Janet T. Orselli Research Consultant cc: Senator Hollings Senator Mattingly	Need	Section 1.1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF S. JACOB SCHERR		
	NATURAL RESOURCES DEFENSE COUNCIL, INC. 1725 I Street, N.W. Suite 600 Washington, D.C. 20006 New York Office Western Office 122 East 42nd Street 25 Kearny Street New York, N.Y. 10168 San Francisco, Calif. 94108 212 949-0049 415 421-6561		
	August 9, 1983		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety, and Environment U.S. Department of Energy Savannah River Operations Office P.O. Box A Aiken, South Carolina 29801		
	Dear Mr. Sires:		
	COMMENTS ON THE SCOPE OF <u>THE L-REACTOR ENVIRONMENTAL IMPACT STATEMENT</u>		
	I am writing on behalf of the Natural Resources Defense Council, Energy Research Foundation, The Georgia Conservancy, Coastal Citizens for Clean Energy, Environmental Policy Institute, S. David Stoney, Justin Stephens McMillan, and Judith Gordon, in response to the Department of Energy's Notice of Intent ("NOI"), 48 Fed. Reg. 32966 (July 19, 1983), to initiate the preparation of an Environmental Impact Statement ("EIS"), pursuant to the National Environmental Policy Act of 1969, as amended ("NEPA"), 42 U.S.C. 4321 et seq. and DOE's implementing regulations and guidelines, on the proposed restoration and operation of the L-Reactor at the Savannah River Plant ("SRP") near Aiken, South Carolina.		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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The above-named organizations and individuals are plaintiffs in the case of NRDC et al. v. Vaughan, C.A. No. 82-3173 (July 15, 1983), which held that the DOE decision of August 21, 1982 not to prepare an EIS on the L-Reactor Project was "arbitrary" and an "abuse of discretion." Thus, they have substantial interest in the preparation and review of an adequate EIS, which has now been ordered by the Court and the Congress.^{1/}

We assume that DOE, in accordance with NEPA, will address clearly and fully the environmental impacts of the L-Reactor, particularly those which have been repeatedly identified as matters of concern in litigation, Congressional and administrative hearings, and statements, letters and other comments of Federal and State officials and technical personnel, and the public. We assume that DOE will make a concerted effort to fill the existing gaps in knowledge regarding the impacts of the L-Reactor which have been previously pointed out and will be discussed briefly below. It is our expectation that DOE, drawing mostly upon studies already completed or underway, will prepare an EIS which is the equivalent to that required for a commercial nuclear reactor, such as those at the Vogtle Nuclear Power Station across the Savannah River from SRP. We anticipate that DOE will give objective consideration to all reasonable alternatives, particularly those other than the one now preferred by DOE. Finally, we hope that DOE will carry out a full and fair NEPA review under the time constraints, which unfortunately here are the result of DOE's failure to properly begin the EIS process more than two years ago.^{2/}

^{1/} The NOI fails to note that DOE's Finding of No Significant Impact regarding the proposed operation of the L-Reactor, 47 Fed. Reg. 36691 (August 23, 1982), no longer has any legal validity as a result of the decision of the Court. Future DOE statements regarding the NEPA process for the L-Reactor should reflect this fact.

^{2/} An NOI to prepare an EIS on the L-Reactor was drafted in Spring 1981, but never published.

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AJ1	We ask DOE to exercise its discretion and provide the public and Federal and State agencies with a 45-day period for review and comment upon the L-Reactor Draft EIS. Given the serious concerns about the L-Reactor's operation as now proposed, the additional two weeks is necessary to assure a more meaningful opportunity for outside, independent technical review by other Federal agencies, State agencies, and the public. We believe that this request can be accommodated within the five-and-one-half months in which DOE is to complete the NEPA process.	NEPA procedures	Foreword
AJ2	We also request that a hearing be held in Washington, D.C. during the public comment period on the Draft EIS. There is substantial national interest in the L-Reactor, and the decisions on the proposed startup and mitigation measures will ultimately have to be made by DOE and Congress in Washington. A hearing there would serve two important public interests recognized by NEPA. It would foster public participation in the EIS process and would contribute to a better-informed decision on the L-Reactor. Our specific comments on the proposed scope of the EIS are as follows: <u>NEED FOR THE L-REACTOR</u>	NEPA Procedures	Public hearings will be held in S.C. and Georgia.
AJ3	The Draft EIS should contain a detailed justification for the proposed startup of the L-Reactor, particularly in regard to its timing which has bearing on the operational alternatives which would eliminate or reduce the environmental harm and hazard associated with its proposed operation. In light of public statements of DOE officials and changes in warhead requirements as a result of Congressional and Administration decisions, there appear to be substantial questions as to the immediacy of the need for the plutonium to be produced by the L-Reactor. DOE representatives have repeatedly testified before Congressional committees that the L-Reactor is needed to meet a possible shortfall in nuclear weapon materials in the early 1990s. Furthermore, as a result of other production initiatives, DOE is now already ahead of its targets to boost the production of these materials. Finally, Congress and the	Need	Section 1.1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	Administration have also apparently reduced the number of warheads scheduled to be produced over the next five years.^{3/} Recently the House Armed Services Committee found that "there is no basis to assume that large numbers of nuclear weapons will be produced in the years beyond 1990."^{4/} <u>ALTERNATIVES</u> <u>Production Alternatives</u>		
AJ4	The Draft EIS should consider as a reasonable alternative a delay in the operation of the L-Reactor for an extended period to allow the implementation of "mitigation alternatives" combined with, if necessary, one or more of the following alternatives: 1. Boosting throughput at the SRP reactors and the N-Reactor, 2. Accelerating the recovery of nuclear materials from the retirement of obsolete warheads, 3. Accelerating development of a new production reactor,	Alternative production	Section 2.1
	^{3/} As one example, the number of warheads for the MX missiles which are now scheduled to be deployed has been reduced from approximately 2000 to 1000. The New York Times, January 16, 1983, reported a DOE official as stating that the L-Reactor will produce each year enough plutonium for some 75 nuclear warheads. Thus, the reduction in the MX program alone suggests that the operation of the L-Reactor may be substantially delayed without risk to our nation's security in order to allow for the implementation of mitigation measures prior to startup. ^{4/} See, e.g., Greenville (S.C.) New, June 7, 1983, at 1-A.		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	4. Accelerating developing of special isotope separation, and 5. Acquiring plutonium from a foreign source. In regard to the first, DOE now plans to install the Mark 15 core in one of the SRP reactors, an action which will increase its plutonium production by approximately 25%. The Draft EIS should address the possibility of the use of such cores in one or more additional reactors on an expedited schedule. In order to provide a rational basis for the choice among the various reasonable production alternatives, including the one of "delay/mitigation," the Draft EIS must provide and disclose to the public, to the fullest extent possible, the following information: 1. Identification of each material production alternative through 1995. 2. Identification by year of the Plutonium-equivalent production capability of each alternative. 3. Identification for each year of the Plutonium-equivalent inventory, stockpile, and future requirements. 4. Indication of precisely which, if any, weapons systems or warheads would have to be delayed if the L-Reactor operation was postponed one, two, three or four years. 5. Indication of whether and how a delay in L-Reactor operation of one or two years would affect the production of warheads already scheduled to 1988, or Plutonium contingency needs in the "out years." <u>Safety System Alternatives</u>		
AJ5	In addition to those mentioned in the NOI, the Draft EIS should consider, to the extent that they have not already been adopted, the following safety alternatives as earlier identified by SRP staff: Detritiation of moderator, Disassembly basin	Safety alternatives	Sections 4.4.1, 4.4.5

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	air confinement, Disassembly basin purge containment, Containment of ECS water in 50m basin, and Heat exchangers.^{5/} <u>Cooling Water Alternatives</u>		
AJ6	The Draft EIS, unlike DOE's earlier Environmental Assessment ("EA"), should fully disclose both the capital and operational costs of each of the alternatives. It should provide complete documentation of the costs and scheduling for each such alternative in order to permit their meaningful outside review. For example, it has been suggested that a cooling tower for the L-Reactor could be constructed for much less money and much more quickly than as estimated in the EA.^{6/} <u>Other Mitigation Alternatives</u>	Alternative cooling	Section 4.4.2, Appendix I See Comment E6
AJ7	In addition to the liquid waste disposal alternatives mentioned in the NOI, the Draft EIS should consider, to the extent that they have not already been adopted or foreclosed, the following alternatives also identified earlier by SRP staff:^{7/} Alternative Steam Supplies (1) Coal-fired boiler at L (2) K to L steam line with back-up oil-fired boiler 186 Basin Sludge Removal (1) Landfill (2) Borrow Pit	Mitigation measures	Section 4.4
^{5/} See Attachment 1 to Memorandum from R. P. Denise, Deputy Manager, SRP, dated August 13, 1981, to F. C. Gilbert, Acting Deputy Assistant Secretary for Nuclear Materials Production, DOE. ^{6/} See 129 Cong. Rec. S10004, July 14, 1983: Statement of Senator Hollings. ^{7/} See Attachment to Denise Memorandum, <u>supra</u> note 5.			

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	Water Intake Structures (1) Modify existing intake structures (2) Reduce pumping capacity (a) Recirculating cooling system (pond) Chlorine Tank (1) Detection Device (2) Nongaseous Sources of Chlorine (3) Move Tanks/Well Enclosure <u>IDENTIFICATION OF ENVIRONMENTAL ISSUES</u> <u>Socioeconomic</u>		
AJ8	The Draft EIS should consider not only employment and other related benefits in South Carolina and Georgia associated with the proposed operation of the L-Reactor, but also the costs. The L-Reactor may contribute to a drain of skilled and technical personnel away from private employers in the region.	Socioeconomics	Sections 5.1.1.1, 5.2.1, Appendix G
AJ9	The socioeconomic effects in the larger Savannah River Basin of accidental releases of radiation and water contamination should also be assessed. An accident could have serious implications for economic development in the region, particularly those areas downstream and downwind of SRP.	Accident analysis	Section 4.2.1, Appendix G
	<u>Endangered Species</u>		
AJ10	DOE should make every effort to facilitate the completion of the consultation with the U.S. Fish and Wildlife Service, pursuant to Section 7 of the Endangered Species Act, in regard to the endangered species which may be affected by the proposed startup of the L-Reactor. The Draft EIS should include also the biological evaluation and the development of mitigation measures for species of "special concern" to the State of South Carolina.	Endangered species	Sections 3.6.1.4, 3.6.2.3, 4.1.1.4, 7.3, Appendix C

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
<u>Fisheries</u>			
AJ11	The Draft EIS should reflect the results of fisheries studies which SRP requested in late 1981 that DuPont prepare to demonstrate the adequacy of SRP cooling water intake structures to meet the requirements of Sec. 316b of the Clean Water Act. In addition, the effects of increased thermal effluents on the Savannah River at the point where they enter the river should be studied and disclosed. The Draft EIS should consider the combined effects upon fisheries of SRP and the Vogtle Nuclear Power Station. In addition to the endangered short-nose sturgeon, attention should be focused upon the American shad, a commercially important fish, and the blueback herring, which is listed as a species of "special concern" by the State of South Carolina.	Fisheries	Sections 5.2.5, 6.1.2, 6.2.4, Appendix C
AJ12		Thermal effects	Sections 4.1.1.4, 4.4.2, 4.4.3.4, 5.1.1.2, 5.2.4, 5.2.5.1
AJ13		Fisheries	Sections 3.6.2.3, 4.1.1.4, Appendix C
<u>Surface Water Usage</u>			
AJ14	The Draft EIS should describe the increase in the withdrawal of Savannah River water for cooling purposes at SRP and any indications of existing and potential conflicts in the use of this resource, such as the proposed hydroelectric facility on the Augusta canal. The adequacy of river flow under drought conditions should also be addressed.	Surface water usage	Sections 4.1.1.2, 5.2.2, 5.1.1.4, Appendix D
AJ15		Alternative cooling	Section 4.4.2, Appendix I See Comment E6
<u>Radiological Effects</u>			
AJ16	The dose commitments from the routine operation of the L-Reactor, including those from radiocesium transport, and from L-Reactor accidental releases should be measured by the same standards and methodology applied to commercial nuclear reactors. The Draft EIS should clearly identify where those standards, namely 10 CFR Parts 50 and 100, would be exceeded by the L-Reactor and by SRP as a multi-reactor site. In regard to the cesium discharges, it should evaluate the concentration of cesium by waterfowl and fish, particularly the American shad, and the effectiveness of cesium-137 removal by water treatment.	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix D, Appendix G
AJ17		Regulatory requirements	Chapter 7 See Comment B7.
AJ18		Radiocesium remobilization	Sections 3.7.2, 4.1.2.4, 4.2.4, Appendix B, Appendix D

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
<u>Safety</u>			
AJ19	The Draft EIS should fully analyze the impacts of all possible reactor accident sequences, including so-called Class 9 accidents, as is required for all commercial nuclear reactors and using the same methodology. It should analyze the environmental, social, and economic effects of accidents up to a full core meltdown. The detailed quantitative analyses, which are needed to support probabilistic estimates of radioactive releases, should be incorporated into the EIS or referenced therein and made freely available to all interested parties. The Draft EIS should include a liquid pathways assessment to analyze the effects of L-Reactor accidental releases upon ground and surface waters, as well as drinking water drawn from the Savannah River.	Accident analysis	Section 4.2.1, Appendix G
<u>Ground-water Contamination</u>			
AJ20	The Draft EIS should contain a clear explanation of the sources and consequences of the existing ground-water contamination at SRP. It should provide full documentation as to the possible movement of contaminants from superficial to deep aquifers.	Groundwater contamination	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, 5.2.3, Appendix F
AJ21	The discussion in the Draft EIS should provide a basis for selection of an alternative to the presently outdated reliance on seepage basins. It should specify whether present SRP	Seepage basins	Section 4.4.3
AJ22	chemical waste disposal procedures conform with the legal requirements of the Resource Conservation and Recovery Act and its implementing regulations. If not, the Draft EIS should detail the steps that will be taken to bring the L-Reactor and SRP into compliance.	Regulatory requirements	Chapter 7
<u>Radioactive Wastes</u>			
AJ23	The Draft EIS should describe the incremental increase in the production of high-level liquid and other radioactive wastes which would result from the proposed operation of the L-Reactor. It should specify what additional commitments of resources would be thus required for the storage and disposal of such wastes, including the construction of more liquid radioactive storage tanks at SRP. The Draft EIS should clearly	Radioactive waste	Sections 4.1.2.8, 5.1.2.8

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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indicate whether the operation of the L-Reactor will result in prolonging the use of older storage tanks at SRP, particularly the single-walled type, two of which have leaked in the past.

*** **

If we can provide further information in regard to these comments, please let me know.

Sincerely yours,

S. Jacob Scherr

Attorney for
Natural Resources Defense Council
Energy Research Foundation
The Georgia Conservancy
Coastal Citizens for Clean Energy
Environmental Policy Institute
S. David Stoney
Justin Stephens McMillan
Judith Gordon

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF THE HONORABLE LINDSAY THOMAS		
	MEMBER OF CONGRESS, FIRST DISTRICT, GEORGIA CONGRESS OF THE UNITED STATES House of Representatives Washington, D.C. 20515		
	August 8, 1983		
	Mr. M. J. Sires, III U.S. Department of Energy Savannah River Operations Office Post Office Box A Aiken, South Carolina 29801		
	Dear Mr. Sires:		
	Please be advised that this presents my additional comments for the Environmental Impact Statement being prepared now in conjunction with the proposed restart of the L-Reactor at the Savannah River Plant (SRP). It is my understanding that my previous statement delivered on February 9, 1983, at the Senate Armed Services Committee hearing in North Augusta, S.C., will also be made part of the EIS record. I am enclosing an additional copy of that statement for reference.		
	As the Representative for the people of the First Congressional District, my comments will focus on the impact of the L-Reactor and the SRP to the health and safety of the 20 counties of the First District.		
AK1	I oppose the restart of the L-Reactor if, in the judgement of	Health effects	Sections 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B, Appendix G Sections 4.2.1, 4.1.1, Appendix G
AK2	the appropriate officials of the State of Georgia, this action presents danger to the health and safety of the people of our state. Georgia officials should have access to all relevant data regarding operational proposals of the SRP as required to assess any health and safety issue which may affect our state.	Accident analysis	

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AK3	I further urge that the EIS on the L-Reactor include an issue which I believe is of even potentially greater import than the L-Reactor. This issue is the cumulative impact of operational expansions of the SRP in combination with the vast array of other nuclear facilities in the Savannah River Basin. The Savannah River Basin continues to become an area of major concentration of nuclear facilities. However, no scientific or environmental evaluation has been made to consider the appropriateness of this buildup. This trend is totally inappropriate for our area due to the extraordinary sensitivity of the local environment and the high population density. The Savannah River Basin now is home to the Chem-Nuclear, Inc. Radioactive Waste Disposal Facility in Barnwell County, South Carolina; the Allied General Nuclear Services-Barnwell Fuel Plant, and commercial nuclear power facilities. The area is the repository for one-third of the defense high-level nuclear waste in the nation. As I stated in my remarks in North Augusta, it is my objective to establish a Federal-State Task Force on the Savannah River Basin which would include the Nuclear Regulatory Commission, the Department of Energy, the Environmental Protection Agency, and the States of Georgia and South Carolina. The organization could provide the oversight necessary to control any proposed cumulative impact, rather than each proposal being handled on a piecemeal basis with no oversight coordination. This would also eliminate the frequent criticism of SRP as being apart from the kind of oversight which is required for private or non-DOE Federal nuclear facilities.	SRP & Regional effects	Section 5.2
AK4	Pending action on such a task force organization, the EIS on the L-Reactor must include a careful analysis of the impact of the restart of the L-Reactor as an additional source of potential nuclear danger in an area which already has more than its share of such facilities. The EIS should include analysis of present and planned nuclear facilities, both private and government, in the Savannah River Basin. The analysis should consider the possibility that the level of activity at nuclear facilities in the area may have to be curtailed in proportion to an increase in activities at the SRP.	Radiological effects	Sections 4.2.1, 5.1.2, Appendix B, Appendix D, Appendix G
AK5		Cumulative radiological effects	Sections 5.1.2, 5.2.6

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
Thank you for your cooperation in including these remarks in your record.	Sincerely,		
	Lindsay Thomas Member of Congress		
Enclosure			

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF RUTH THOMAS		
	ENVIRONMENTALISTS INC. 1339 Sinkler Road Columbia, S.C. 29206 (803) 782-3000		
	August 8, 1983		
	Mr. M. J. Sires, III Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operations Office Post Office Box A Aiken, South Carolina 29801		
	Re: Preparation of an EIS on the proposed restarting of the L-Reactor at the SRP		
	Dear Mr. Sires:		
	In the attached Comments, Environmentalists, Inc. has high- lighted some of the failures in the <u>Environmental Assessment</u> <u>L-Reactor Operations, Savannah River Plant.</u>		
	<i>Consideration of Costs/Benefits and consideration of Alterna-</i> <i>tives were selected as subjects for our Comments, because the</i> <i>National Environmental Policy Act (1969) identifies these</i> <i>matters as crucial to a federal agency's complying with this</i> <i>law's mandate of taking environmental values into account "to</i> <i>the fullest extent possible."</i>		
	The public will be expecting the Department of Energy to cor- rect the deficiencies of the <u>Environmental Assessment</u> report when the agency prepares an <u>Environmental Impact Statement</u>		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	related to the proposed restart of the L-Reactor at the Savannah River Plant.		
	Sincerely,		
	Ruth Thomas Authorized Representative		
	Enclosure cc: Interested persons and organizations		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	ENCLOSURE OF RUTH THOMAS		
	ENVIRONMENTALISTS INC. 1339 Sinkler Road Columbia, S.C. 29206		
	August 8, 1983		
	COMMENTS highlighting A NUMBER OF FAILURES IN THE "ENVIRONMENTAL ASSESSMENT, L-REACTOR OPERATIONS, SAVANNAH RIVER PLANT" WHICH SHOULD NOT BE REPEATED IN THE ENVIRONMENTAL IMPACT STATEMENT PREPARED BY THE DEPARTMENT OF ENERGY		
K-114	A. Failure to provide adequate evidence regarding the costs (damage to the environment and the public's health) of adding to the amount of nuclear contamination released by the proposed restart of the L-Reactor. For example:		
AL1	1. Failure to report thoroughly on <u>any</u> and <u>all</u> radioactive releases which have occurred since operations began at the Savannah River Plant (SRP) in the 1950's.	Radiological effects	Section 5.1.2, 5.2.6
AL2	2. Failure to give adequate attention to the fact that for more than 25 years people living in the SRP region have been continuously subjected to the routine releases of nuclear contamination, a type of poison whose damaging effects are cumulative.	Health effects	Sections 3.7.1, 4.1.2.6, 4.2.1.5, 5.1.2.5, 5.2.7, Appendix B
AL3	3. Failure to fully acknowledge the cumulative aspect of radiation exposure, particularly in terms of its harmful effects due to internal exposure resulting from the inhaling of radioactive particles and the ingesting of radioactively contaminated liquids and foods.	Cumulative radiological effects	Sections 5.1.2, 5.2.6, Appendix B
AL4	4. Failure to provide adequate data for predicting where the concentration of nuclear contamination from SRP's radioactive releases is most likely to exist.	Radiological effects	Sections 4.2.1, 5.1.2, Appendix B, Appendix D

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AL5	5. Failure to provide adequate evidence to support the selection of a monetary value for the worth of a life and a monetary value to represent the loss of a person's health.	Radiological effects	Section 4.4.1.6, Appendix B, Appendix G
AL6	6. Failure to provide the evidence necessary to predict	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix D
AL7	the impact which additional radioactive and thermal pollution is likely to have on the availability of adequate uncontaminated water for present residents and businesses of the region as well as in terms of pure water sources for future growth.	Thermal effects	Sections 4.1.1.4, 4.4.2, 4.4.3.4, 5.2.4, 5.2.5.1
	B. Failure to provide adequate evidence regarding the benefits of restarting the L-Reactor:		
AL8	1. Lack of evidence to support the view that more nuclear weapons would reduce the probability of there being an atomic war.	Need	See Comment D1
AL9	2. Lack of evidence to refute the view that increasing the production of nuclear weapons would increase the probability of there being an atomic war.	Need	See Comment D1
	C. Failure to adequately study, develop and describe alternatives to the restart of the L-Reactor as this operation is being proposed:		
AL10	1. Failure to provide adequate evidence regarding the alternative of delaying the restart of the L-Reactor.	Alternative production	Section 2.3
AL11	2. Failure to provide adequate evidence regarding the alternative of updating the once through cooling water proposal, in terms of reducing the flushing of radioactive contamination into water sources, in terms of using large quantities of water for cooling, in terms of reducing destruction of plant and animal life.	Alternative cooling	Section 4.4.2 See Comment E6
AL12	3. Failure to provide adequate evidence regarding the alternative of a new reactor.	Alternative production	Section 2.1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AL13	4. Failure to study, develop and describe alternatives to producing more nuclear weapons, such as increasing peace efforts and reducing the production of nuclear weapons. Respectfully submitted by, Ruth Thomas Authorized Representative	Need	See Comment D1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	LETTER OF THE HONORABLE STROM THURMOND THE PRESIDENT PRO TEMPORE UNITED STATES SENATE August 4, 1983 Mr. Richard P. Denise Acting Manager Department of Energy Savannah River Operations Office Post Office Box A Aiken, South Carolina 29801 Dear Mr. Denise: Thank you for your invitation to participate in the scoping process associated with the expedited Environmental Impact Statement (EIS) for the restart of the L-Reactor at the Savannah River Plant in Aiken, South Carolina. While I do not plan to actively participate in the scoping process, I wish to take this opportunity to briefly comment on several aspects of the L-Reactor EIS and to summarize for the record my involvement with this issue. As you know, my involvement with the Savannah River Plant site, its programs, and the L-Reactor restart has been extensive. For many years I have worked for effective national defense programs at the site while seeking the fullest protection for the health and safety of citizens in the surrounding area and for the environment. When environmental concerns regarding the L-Reactor were raised, I arranged for the Senate Armed Services Committee to hold a field hearing in North Augusta, South Carolina, and chaired that hearing. Subsequently, along with Senator Mattingly, I secured written commitments from Secretary Hodel to: (1) undertake a further public review and hearing process to thoroughly brief the public on plans for the reactor restart and to answer questions from the public; (2) conduct further		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
thermal studies for all Savannah River Plant effluent streams as they impact on the Savannah River; (3) conduct comprehensive epidemiological studies associated with the L-Reactor restart; and (4) operate the L-Reactor within the limits set by the environmental assessment or modify operations as necessary to achieve compliance. I sent a staff representative to each of the eight additional public hearings held in South Carolina and Georgia that were conducted by the Energy Department in fulfillment of the first of Secretary Hodel's commitments to me and Senator Mattingly.			
AM1	As you are aware, I have recently supported three important amendments regarding the Savannah River Plant site. The first, an amendment to the FY 1984 Energy and Water Appropriations bill, requires the Energy Department to complete an expedited EIS on the L-Reactor. While I do not feel an EIS at this juncture will be particularly enlightening or productive, I supported that amendment because it improved an earlier proposal and offered an opportunity to facilitate the restart of the L-Reactor with a minimum delay. Now that an EIS has been mandated, both by Congress and a Federal District Court decision, I urge the Energy Department to make a thorough and complete study which will withstand the test of sufficiency and thereby avoid the possibility of further delays in restart.	NEPA procedures	Foreword
AM2	A second amendment was offered by me in the Senate Armed Services Committee during markup of the 1984 Department of Defense Authorization bill. It requires the Department of Energy to phase out some of its seepage basins and to clean up any existing chemical contaminants that may threaten our important groundwater resources. I would like to commend the Department of Energy for identifying this problem in a timely manner and for cooperating in seeking a responsible solution. I suggest that the relationship between the L-Reactor restart and the chemical groundwater contamination problem be addressed in the EIS to establish whether or not these issues are closely linked.	Groundwater	Sections 4.1.2.2, 4.4.3, 5.1.1.2, 5.1.1.4, Appendix F
	The third amendment, also an amendment to the 1984 Department of Defense Authorization bill, requires mitigation of the thermal effects associated with the L-Reactor as soon as practical and prior to restart unless the President determines that		

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	the delay involved will jeopardize national security. I supported that amendment, which the Department of Energy requested, as a reasonable approach to addressing both the environmental and national security concerns.		
AM3	In addition, I wish to take this opportunity to encourage the Department of Energy to continue its careful monitoring of the operations at the site and to continue seeking operational improvements that will enhance the protection of our citizens and the environment. I hope that the Department of Energy will strive for increased public understanding of site operations because I believe that openness and factual information are the keys to public trust. In return, the Department of Energy may remain assured of my continued strong support and cooperation with respect to the Savannah River Plant programs. With kindest regards and best wishes, Sincerely, Strom Thurmond	Monitoring	Sections 6.1, 6.2
ST/jjd			

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF ELWIN R. TILSON			
206 E. Liberty St. Savannah, GA 31401 August 10, 1983 M. J. Sires, III Asst. Manager for Health, Safety, and Environment Savannah River Operations Office P.O. Box A Aiken, S.C. 29801 Dear Mr. Sires: I am requesting that this letter be included in the Scoping process for the EIS being done on the L-Reactor. The following are areas of concern that I want addressed in the EIS:			
AN1	1. DOE documents indicate that 10,500 Ci of Tritium will be dumped into seepage basins from the L-Reactor in addition to substantial amounts of toxic wastes. Please address the long term effects of seepage basin usage to ground water and surface water sources.	Seepage basins	Section 4.4.3
AN2	2. DOE documents indicate that 7,800 acres of emergent wetlands adjacent to the river are on the SRP. Presently, 5,000 acres of wetlands have been seriously altered or destroyed and another 1,000-1,100 acres will become a "sacrifice zone" with the restart of the L-Reactor. Please see how such extensive alteration or destruction of wetlands can be declared as NSI.	Wetlands	Sections 4.1.1.4, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
AN3	3. New standards for airborne radioisotopes were due to be published on March 29, 1983. What effect do the new standards have on the operation of the L-Reactor and how will the DOE meet them?	Regulatory requirements	Chapter 7
AN4	4. NEPA 43FR230 Sec 433.1 states that the operating facility must "restore and maintain environment." How can the	Endangered species	Sections 3.6.1.4, 3.6.2.3, 4.1.1.4, Appendix C

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	proposed destruction of 1,100 acres of wetland used by four species of threatened or endangered animals meet the NEPA requirements?		
AN5	5. A study done by the NUS Corporation indicated that the use of Steel Creek as a discharge/cooling system would be the most expensive to maintain, cause the greatest Cs137 transportation, make the greatest demands on Savannah River flow rates, be one of the highest sources of liquid effluent, have the highest impact on the environment, have the highest impact on endangered or threatened species, and have a high impact on archaeological resources. Please address how such costly option can be justified for use with the L-Reactor reactivation.	Alternative cooling	Section 4.4.2 See Comment E6
AN6	6. The Savannah River Ecology Lab reports (SREL-9, UC66e & SREL-11, UC66e) state that "additional study is needed to determine wetland degradation on migratory fish" before the L-Reactor is restarted. Please include such studies in the EIS.	Fisheries	Section 6.2.5
AN7	7. The SREL reports also state that "spring (season) studies are needed" before the restart of the L-Reactor. Please include such studies in the EIS.	Fisheries	Section 6.2.5
AN8	8. The EA misquotes the SREL-11 report in that the EA gives bioaccumulation a rating of 2,019. The SREL-11 report states that the rating is <u>conservatively</u> 3,000 and can be as high as 6,000 for large game fish. Please review the use of support documents used in the EA before using in the EIS and also address why bioaccumulation discrepancies occurred.	Radiological effects	Appendix B
AN9	9. NCR criteria 10 CFR part 100 require containment domes for <u>all</u> commercial reactors as a minimum safety system. Please <u>address</u> how the L-Reactor be declared acceptably safe without a requirement necessary for most reactors in this country.	Safety alternatives	Section 4.4.1.5
AN10	10. Please address how the L-Reactor operation can be considered in compliance with the concept of ALARA as outlined by the NCRP when large amounts of Cs137 and Tritium are routinely dumped into the environment.	Radiological effects	Section 4.2.1, 5.1.2, Appendix B, Appendix G

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AN11	11. DuPont studies indicate that the reactor type used in L-Reactor has a history of coolant pipe leakage which would cause meltdown. Please address how the L-Reactor design has been modified to offset this historical problem.	Accident analysis	Section 4.2.1, Appendix G
AN12	12. Please include an independent safety review of the L-Reactor within the EIS.	Accident analysis	Section 4.2.1.2
AN13	13. The EA ignored a worst case study done by DuPont (EID L-Reactor Reactivation, p. 5-28: DPST-81-241, April 1982). The Du Pont study indicate that public dose rates to the thyroid from a worst case accident would be unacceptably high. Please include this study in calculations used in the EIS.	Accident analysis	Section 4.1.2.5, Appendix D
AN14	14. Please address the validity of radioisotope remobilization in Steel Creek in light of the constant changes in the levels reported with each different recalculation.	Radiocesium remobilization	Section 4.1.2.4, Appendix D
AN15	15. All accident probability calculations in the EA were based on single safety system failures. Please include multiple system failures when calculating accident probabilities in the EIS.	Accident analysis	Section 4.2.1, Appendix G
AN16	16. DPST-81-241, April 1982 states that radiocesium remobilization in Steel Creek would give a maximum individual dose of 10.5 mrem/yr. The EA states the MID would be only 5 mrem/yr. Please address this discrepancy and reanalyze data and assumptions used.	Radiocesium remobilization	Section 4.1.2.4, Appendix D
AN17	17. NPDES permits do not allow the SRP to increase the temperature of the Savannah River by the 1.25-1.5 degrees which will occur when the L-Reactor comes on line. Please address how SRP will keep within NPDES limits.	Thermal effects	Sections 4.1.1.4, 7.2.4
AN18	18. No study has been done on the thermal effects at the mouth of Steel Creek which is a major sports fishing area. Please include such studies in the EIS and also include thermal monitoring closer than the present six miles downstream.	Thermal effects	Section 5.2.5.1
AN19	19. No study has been done on thermal plumes. Please include such studies in the EIS.	Thermal effects	Sections 4.1.1.4, 5.2.4.2

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
AN20	20. No study has been done on the <u>long term</u> effects of accumulation of radionuclides in the Beaufort-Jasper water system. Please include such a study in the EIS.	Cumulative radiological effects	Sections 5.1.2, 5.2.6
AN21	21. The EA states that it assumes that there was "complete mixing in the river" of radiocesium when dose rates were calculated. This assumption needs reevaluation as it ignores accumulation of radiocesium in the environment and also does not take into consideration actual mixing processes in rivers. Please address this discrepancy and re-evaluate calculations.	Radiocesium remobilization	Sections 4.1.2.4, Appendix B, Appendix D
AN22	22. Evaluate the environmental (specifically radiologic) impact of the restart of the L-Reactor <u>in conjunction</u> with existing impacts from other facilities at the SMP.	Cumulative radiological effects	Sections 5.1.2, 5.2.6
	Your attention to these concerns in the EIS is appreciated.		

Elwin R. Tilson

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF ALFRED H. VANG			
EXECUTIVE DIRECTOR STATE OF SOUTH CAROLINA WATER RESOURCES COMMISSION P.O. Box 50506/1001 Harden Street, Suite 250 Columbia, S.C. 29250 (803) 758-2514			
August 9, 1983			
Mr. M. J. Sires, III Assistant Manager for Health, Safety and Environment U.S. Department of Energy Savannah River Operations Office P.O. Box A Aiken, South Carolina 29801			
Dear Mr. Sires:			
The South Carolina Water Resources Commission staff has prepared the following comments for inclusion in the scoping process for the L-Reactor Restart Environmental Impact Statement. Please consider these comments and suggestions in your development of the Draft EIS.			
A01	1. Within limits imposed by national security considerations, we feel the EIS should provide a solid justification of the actual need for L-Reactor restart. The requirement for additional nuclear materials should be clearly documented.	Need	Section 1.1
A02	2. All State and Federal regulatory requirements pertinent to restart should be indicated along with DOE's intentions and methods to comply with these requirements. If there are any regulatory requirements which apply to private industrial facilities with similar potential impacts but do not apply to L-Reactor, these should be indicated along with the authorization for exemption. Any areas of L-Reactor operation which are not regulated by a State or Federal agency other than DOE should be identified.	Regulatory requirements	Chapter 7

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
A03	3. It is the position of the Water Resources Commission that the L-Reactor should be in compliance with State water quality standards for temperature at the time of initial restart. The EIS should clearly indicate if, how, and when this compliance will be accomplished.	Regulatory requirements	Chapter 7
A04	4. The EIS should contain a thorough evaluation of the effect of operation on surface water use throughout the Savannah River Basin. Surface water availability along with current and projected water uses, diversions, and interbasin transfer should be included in this evaluation. Since Savannah River flows of less than the 7Q10 level have occurred in the recent past, consideration of these low flows should be included in the evaluation. The consumptive loss of water due to L-Reactor alone, and in combination with other SRP operations, should be assessed.	Surface water use	Sections 4.1.1.2, 5.1.1.4, 5.2.2
A05	5. In assessing the impacts of restart, baseline environmental conditions considered should be those existing prior to the 1954-1968 period of previous operation. It is obvious from the Environmental Assessment that significant adverse impacts occurred during 1954-1968, with some recovery occurring since L-Reactor shut-down in 1968. We do not feel it legitimate to compare expected impacts of restart with the earlier period of documented environmental damage. The real issue is how the restart effects will differ from those that would exist if L-Reactor had never been constructed or operated.	NEPA procedures	Section 3.6, Appendix C
A06	6. Assessment of all restart impacts upon onsite environmental conditions and natural resources should be clearly related to corresponding effects on offsite conditions and resources. For example--what effect would the loss of fish and wildlife habitat in Steel Creek and associated wetlands have on fish and wildlife populations offsite?	Wetlands impacts	Sections 4.1.1, 4.4.2, 5.1.1.2, 5.2.4, Appendix C, Appendix I
A07	7. All releases and resuspensions of radioactive materials, whether routine or accidental, should be thoroughly addressed with regard to impacts on the environment and human populations. L-Reactor releases should be assessed in view of all other existing and potential sources of radioactive releases. Individual sources of release may not be considered significant, but the cumulative effect of multiple releases may be of	Radiological effects	Sections 4.2.1, 5.1.2, 5.2.6, Appendix B, Appendix D, Appendix G

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
A08	concern. It should be pointed out that there is no totally safe radiation dose level and that adverse biological effects, such as genetic effects can occur from even minute amounts of radiation. The assessment of radiological impacts should include a discussion of relevant regulations and standards and how these regulations and standards compare with those imposed on private industry.	Regulatory requirements	Chapter 7
A09	8. Our staff has the following specific ground water concerns relevant to L-Reactor restart. We suggest that these concerns be thoroughly addressed in the EIS. (a) Shallow ground water beneath the L-Area site moves generally either to the south-southeast or west-southwest; however, in areas where the confining bed is thin or absent, downward movement takes place presenting a potential for contamination of underlying aquifers. (b) Approximately 6000 wells have been drilled at the SRP. Many of these (approximately 600) were pre-existing domestic wells; some penetrating the Tuscaloosa, that have been abandoned. The status of these wells is not known, but any open holes or rusted-out casings provide a direct route for water from contaminated shallow aquifers to the Tuscaloosa. (c) The restart of L-Reactor is expected to increase deposits to the sanitary land fill. Metals, organics, and other contaminants have definitely increased in the ground water as a result of the disposal sites, some in excess of U.S. EPA drinking water standards. Two wells penetrating the Tuscaloosa formation have been abandoned because of the high levels of Triclene, Perclene, and TCE. (d) The presence of mica and kaolinitic clays in the subsurface will make ion exchange a significant problem in controlling the movement of contaminants in ground water, especially in the McBean formation. (e) Ground-water levels in the Tuscaloosa formation have definitely declined from 1965-1982. Water use by the L-Area (300 gpm) should add to these declines.	Groundwater contamination	Sections 4.1.2, 5.1.1.2, 5.1.1.4, Appendix F

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
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(f) Approximately 5,000 Ci of tritium have migrated southwest of the burial grounds and are contained in the ground-water. Any additional disposal of tritium would add to the problem.

A010

9. The EIS should include a thorough evaluation of economic impacts on the immediate area and the entire State of South Carolina. This evaluation should include assessment of environmental effects, whether real or perceived, on recreation, tourism, future industrial development, and general economic well-being.

Socioeconomics

Sections 4.1.1.1, 4.2.1.5, 5.1.1.1, 5.2.1

In addition to the above comments, there have been numerous suggestions and areas of concern expressed at public hearings and through other avenues of public input. We encourage you to consider and address all of these concerns in your preparation of the EIS.

Thank you for the opportunity to submit the above comments for inclusion in your scoping process. Please feel free to contact me if you have any questions in this matter.

Sincerely,

Alfred H. Vang
Executive Director

AHV:cw

cc: S.C. Water Resources Commissioners

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
LETTER OF LAURA WORBY			
NUCLEAR INFORMATION AND RESOURCE SERVICE 1346 Connecticut Avenue, N.W., 4th Floor Washington, D.C. 20036 (202) 296-7552 August 5, 1983 Mr. M. J. Sires III Asst. Manager for Health, Safety and Environment U.S. DOE Savannah River Operations Office P.O. Box A Aiken, S.C. 29801 Dear Mr. Sires: This is in regard to the July 19, 1983 Federal Register Notice of intent to prepare an environmental impact statement (EIS) pertaining to the proposed resumption of L-Reactor operation at the Savannah River Plant. The Nuclear Information and Resource Service (NIRS) is a non-profit, membership organization which provides information and organizing assistance to citizens concerned about nuclear issues. Our interest in the L-Reactor EIS stems from our goal to facilitate maximum public discussion and participation in nuclear-related decisions, and our concern that military and civilian applications of nuclear technology be held to the same standards for protecting public health and safety and the environment.			
AP1	With regard to the scope of the EIS, we anticipate that the Secretary will examine all reasonable alternatives to production of plutonium in the L-Reactor. These alternatives should include the option of no plutonium production at all, as well as the production of plutonium in reactors other than the L-Reactor. In evaluating the alternatives, DOE must carefully consider and justify the need for additional plutonium. In justifying the need for plutonium, DOE should discuss recent reductions in projected warhead production, as well as the development of other sources of plutonium. These issues	Alternative production	Section 2.1
AP2		Need	Section 1.1 See Comment D1

Table K-5. Scoping letters and EIS sections or DOE's responses (continued)

Comment number	Scoping letter	Scoping topic	EIS section or DOE comment
	deserve the most searching analysis, particularly at a time when the majority of U.S. citizens support at least a freeze, if not a reduction in the U.S. nuclear arsenal, which already contains some 25,000 thermonuclear warheads. We suggest that this question be addressed on an unclassified basis to the extent possible, so that it can be the subject of informed and intelligent public debate.		
AP3	If DOE finds that L-Reactor operation is the preferred option, the discussion of alternatives should examine the option of delaying start-up of the reactor, so that measures to mitigate environmental impacts and to improve the safety of the reactor may be taken.	Alternative production	Section 2.1
AP4	Regarding procedures for public review of the draft EIS, we ask the DOE provide 45 days for public and Federal and state agency review and comment on the document. The additional two weeks will allow commenters to provide more meaningful input, without significantly compromising DOE's ability to meet its 5-1/2 month schedule for completing the NEPA process. We also	NEPA procedures	Foreword
AP5	request that DOE hold a hearing in Washington, D.C. on the draft EIS as well as in South Carolina, in view of the substantial national interest in the L-Reactor. In addition, since the major decisions regarding start-up and mitigation measures will be made at DOE headquarters and by Congress in Washington, participation by members of the public and organizations in Washington will contribute to a better informed decision on the L-Reactor.	NEPA procedures	Hearings are being held in South Carolina and Georgia.

Please send a copy of the draft EIS when it is available.
Thank you very much.

Sincerely,

Laura Worby
Radioactive Waste Specialist

APPENDIX L

ASSESSMENT OF PREFERRED COOLING-WATER ALTERNATIVE*

L.1 OBJECTIVE

The purpose of this appendix is to present a detailed, "standalone" assessment of the preferred cooling-water mitigation alternative supplementing the material in Section 4.5.

The preferred cooling-water alternative of the Department of Energy is to construct a 1000-acre lake before L-Reactor resumes operation, to redesign the reactor outfall, and to operate L-Reactor in a way (i.e., reduced reactor power when necessary) that assures a balanced biological community in the lake as specified in an NPDES permit to be issued by the State of South Carolina. The impacts from the 1000-acre lake are bracketed by the impacts from the 500-acre lake and the 1300-acre lake described in the Draft EIS.

The lake will require an anticipated minimum period of 3 to 5 years to establish and develop a balanced biological community. Initially, L-Reactor will be operated to maintain 32.2°C or less in about 50 percent of the lake. Studies will be conducted to confirm the biological characteristics and the cooling effectiveness of the lake. Following the results of these studies, L-Reactor operations will be adjusted as necessary to assure the continued maintenance of a balanced biological community.

In the Draft EIS issued in September 1983, the Department of Energy reviewed and evaluated specific cooling-water alternatives for L-Reactor. Based on the comments submitted during the public review and comment period, the Department has expanded the discussion of potential cooling-water alternatives in this Final EIS. Specifically, Section 4.4.2 now provides detailed discussions of additional combinations of engineered cooling-water systems and additional cooling-lake alternatives. The Department has also evaluated each alternative for attaining the thermal discharge standards of the State of South Carolina.

This review included new data from the U.S. Army Corps of Engineers, stating that they could complete construction of a lake on Steel Creek as large as 1000 acres within 6 months on an expedited basis. On this basis, DOE selected the 1000-acre cooling lake as its preferred cooling alternative for the L-Reactor restart because it would:

1. Meet all state and Federal regulatory and environmental requirements, substantially reducing or eliminating thermal impacts on the river, swamp, and unimpounded stream, while providing a productive balanced biological community within the lake.
2. Provide the earliest reactor startup and the maximum plutonium deliveries of any environmentally acceptable cooling-water alternative meeting regulatory requirements.

*Because this appendix is new, it does not require vertical change bars.

3. Have the lowest costs of any environmentally acceptable cooling-water alternative meeting regulatory requirements.
4. Be amenable to backfitting with precooler systems, if needed, which could improve reactor operational flexibility and the production capability.

Under the Atomic Energy Act of 1954, the Department of Energy is responsible for developing and maintaining the capability to produce all defense nuclear materials required for the U.S. weapons program. The requirements for defense nuclear materials are contained in a classified document--the Nuclear Weapons Stockpile Memorandum--that is approved by the President. In the development of this memorandum, many factors are considered, including the needs of the armed services; the current status of legislative actions on weapons systems and production capability; and the current status of material inventory, material supply from weapon retirements, material production, and weapons fabrication.

The additional requirements for plutonium are contained in the Nuclear Weapons Stockpile Memorandum for fiscal years 1984 through 1989 approved by President Reagan on February 16, 1984. This current Nuclear Weapons Stockpile Memorandum defines the annual requirements for defense nuclear materials for 5 years (fiscal years 1984 through 1989), the planning directives for the next 5-year period, and 5 additional years of projections for long-range planning. In his approval of this Stockpile Memorandum, President Reagan emphasized the importance of meeting these annual requirements and maintaining an adequate supply of defense nuclear materials by directing that: "As a matter of policy, national security requirements shall be the limiting factor in the nuclear force structure. Arbitrary constraints on nuclear materials availability shall not be allowed to jeopardize attainment of the forces required to assure our defense and maintain deterrence. Accordingly, DOE shall . . . assure the capability to meet current and projected needs for nuclear materials and . . . restart the L-Reactor at the Savannah River Plant, Aiken, S.C., as soon as possible."

The specific need for L-Reactor is supported by quantitative analyses of the production capabilities of DOE facilities and the requirements set forth in the Nuclear Weapons Stockpile Memorandum. This information is classified in accordance with the Atomic Energy Act of 1954. A classified appendix to this EIS (Appendix A) provides a quantitative evaluation of the need for L-Reactor based on the latest approved Nuclear Weapons Stockpile Memorandum. The quantitative analysis in Appendix A supports the need to restart L-Reactor as soon as practicable.

Pursuant to Federal regulations on the discharge of dredged or fill material into navigable waters (40 CFR 230), several other alternatives were identified and discussed in Section 4.4.2 "which would have less adverse impact on the aquatic ecosystem" (40 CFR 230.10a). These included the recirculating alternatives and the once-through cooling tower with a separate canal and pipe to the Savannah River. None of these alternatives can be implemented in time to meet the need for nuclear materials, and all are more expensive and would delay reactor startup significantly. These alternatives were, therefore, rejected as impracticable when considered "in light of overall project purpose" (40 CFR 230.10a2); i.e., developing and maintaining the capability to produce defense nuclear materials required for the U.S. weapons program.

The primary contenders of the 1000-acre lake alternative are recirculating mechanical-draft cooling towers of the type described in Section 4.4.2.3.2. The best of these towers is, thus, the "best available technology." For purposes of life-cycle comparison, the 1000-acre lake is assumed to cost about \$25 million; allow a reactor startup of February 1, 1985; and require an initial (averaged) reactor power reduction of 14 percent, which can be reduced to about 3 percent by February 1, 1987, by the expenditure of approximately \$10 million for pre-coolers to improve lake performance. Similarly, it is assumed that the most efficient 2.8°C approach towers are used, which would cost from \$60 to \$75 million to construct (depending on blowdown treatment), allow a reactor startup of September 1986, and require a reactor power reduction of 6.5 percent (Grandall, 1984).

The life-cycle cost of the 1000-acre lake (i.e., construction, operation, and loss of production including the later startup of the cooling tower) is almost three times less than that of the recirculating cooling tower; this large advantage will persist over any other cooling alternative that meets current regulatory criteria.

The preferred alternative (1000-acre lake) can meet the State of South Carolina criteria and be implemented in the shortest time period to allow DOE to restart L-Reactor as soon as possible.

Although the preferred alternative may have more adverse impacts to the aquatic ecosystem than some of the alternatives discussed in Section 4.4.2, the Department of Energy has committed to initiating several additional mitigation measures to offset any potential adverse impacts for the preferred alternative:

- Funding long-term studies to assure a balanced biological community in the lake and downstream from the embankment.
- Developing a monitoring and mitigation plan for historic/archeological sites to ensure the preservation of the resources at the four sites below the embankment; the plan has been approved by the South Carolina State Historic Preservation Officer (SHPO) (Du Pont, 1983a). A resource recovery plan has been developed by the University of South Carolina Institute of Archeology and Anthropology for the one historic site (38 BR 288) located within the proposed lake area. This mitigation plan has been approved by the SHPO and the Advisory Council on Historic Preservation (ACHP) (Lee, 1982), which concurred that this mitigation plan will result in no adverse impacts to National Register properties. Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina, Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). The study results, the determination of eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

- Working with the Department of the Interior to perform a Habitat Evaluation Procedure (HEP). The HEP will identify the value of habitat to be gained or lost with implementation of the preferred cooling-water mitigation alternative for use in assessing further mitigation. If required, DOE will implement additional mitigative measures that might be identified through the HEP process, dependent on Congressional authorization and appropriation.
- The endangered wood stork forages at the Savannah River Plant but does not breed on the site. The feeding individuals have been observed to be from the Birdsville Rookery, some 50 kilometers away. Feeding occurs in the swamp downstream of the proposed lake; it could be affected by raised water levels of the Steel Creek delta if the L-Reactor cooling-water flow is discharged through the proposed lake. DOE initiated informal consultation with the U.S. Fish and Wildlife Service (FWS) in July 1983 as allowed by Section 7 of the Endangered Species Act. DOE has also initiated the formal consultation process by providing a Biological Assessment to FWS for a Biological Opinion (Sires, 1984a). While DOE concludes that the operation of L-Reactor will affect foraging habitat near the Steel Creek delta, the construction activities associated with Phase II of the NPDES permit to control the acidity of releases from the 400-area powerhouse ash basins will improve the quality of the foraging habitat in the Beaver Dam Creek area, assuring the continued availability of this habitat. Therefore, the loss of foraging habitat in the Steel Creek area should not jeopardize the continued existence of the wood stork. Any additional mitigation measures needed will be determined either as part of the HEP study or as part of this consultation process. DOE will also continue to fund long-term studies of the wood stork and its relationship to SRP.
- The 1000-acre lake construction activity would include an Environmental Protection Plan (see Section L.2.4.8.3).
- Construction of the lake will include shoreline refuge areas to enhance the biological productivity of the lake.

In accordance with Section 313 of the Federal Water Pollution Control Act, the 1000-acre cooling lake was compared with "innovative treatment processes and techniques" (e.g., thermal cogeneration). As discussed in Section 4.4.2.5.1, the costs of these innovative treatment processes would be significantly higher than those of the 1000-acre lake, would require as long as 12 years to implement, and would not meet State of South Carolina standards. Thus, these alternatives were considered impracticable in terms of cost, schedule, and compliance with standards to meet the overall project purpose.

The preferred alternative will meet the South Carolina standards within the necessary time frame to fulfill the need for nuclear materials. Thus, the preferred alternative with the implemented mitigation measures to offset adverse impacts constitutes the most practicable alternative to meet the overall project purpose.

L.2 SUMMARY

The preferred cooling alternative proposed for mitigating thermal impacts on Steel Creek and swamp is to form a 1000-acre cooling lake by constructing an embankment across Steel Creek (Figure L-1).

L.2.1 Description

The description in the following sections is representative of the lake design, but the detail is not exact (e.g., embankment dimensions) because the final design has not been completed.

L.2.1.1 Lake

The 1000-acre lake would be about 1200 meters wide at its widest point, averaging approximately 600 meters, and would extend about 7000 meters along the Steel Creek valley from the embankment to just beyond Road B (Figure L-2). The normal pool elevation of the lake would be 58 meters above mean sea level (MSL); the present elevation of Steel Creek at the dam site is 35 meters. The storage volume at the normal pool elevation would be about 31 million cubic meters.

L.2.1.2 Embankment

The embankment would be approximately 800 meters upstream from the Seaboard Coast Line Railroad Bridge across Steel Creek or 1700 meters upstream from Road A. It would be 1200 meters long at the crest which includes approximately 600 meters of low embankment connecting the west end of the main embankment to the natural ground at elevation 61 meters above mean sea level (Figure L-3). The main embankment would be a maximum of about 26 meters high, 12 meters wide at the top, and 200 meters wide at the base. The elevation at the top of the embankment would be 61 meters above mean sea level to allow 3 meters freeboard for flood pool, wave action, and earthquake settlement.

A paved road would be constructed along the top of the embankment to provide access for operation and maintenance. An outlet structure with gates would control the discharge from the lake to a conduit running 220 meters under the embankment. This conduit would discharge into a stilling basin to reduce the velocity before the water is released into Steel Creek.

A natural "saddle" in the ridge line between Steel Creek and Pen Branch watersheds is the lowest point in the drainage divide around the lake. This area, which has a low-point elevation 60 meters above mean sea level, would function temporarily as an emergency spillway to bypass extreme floods and prevent overtopping of the embankment. An engineered spillway would be constructed at a later date.

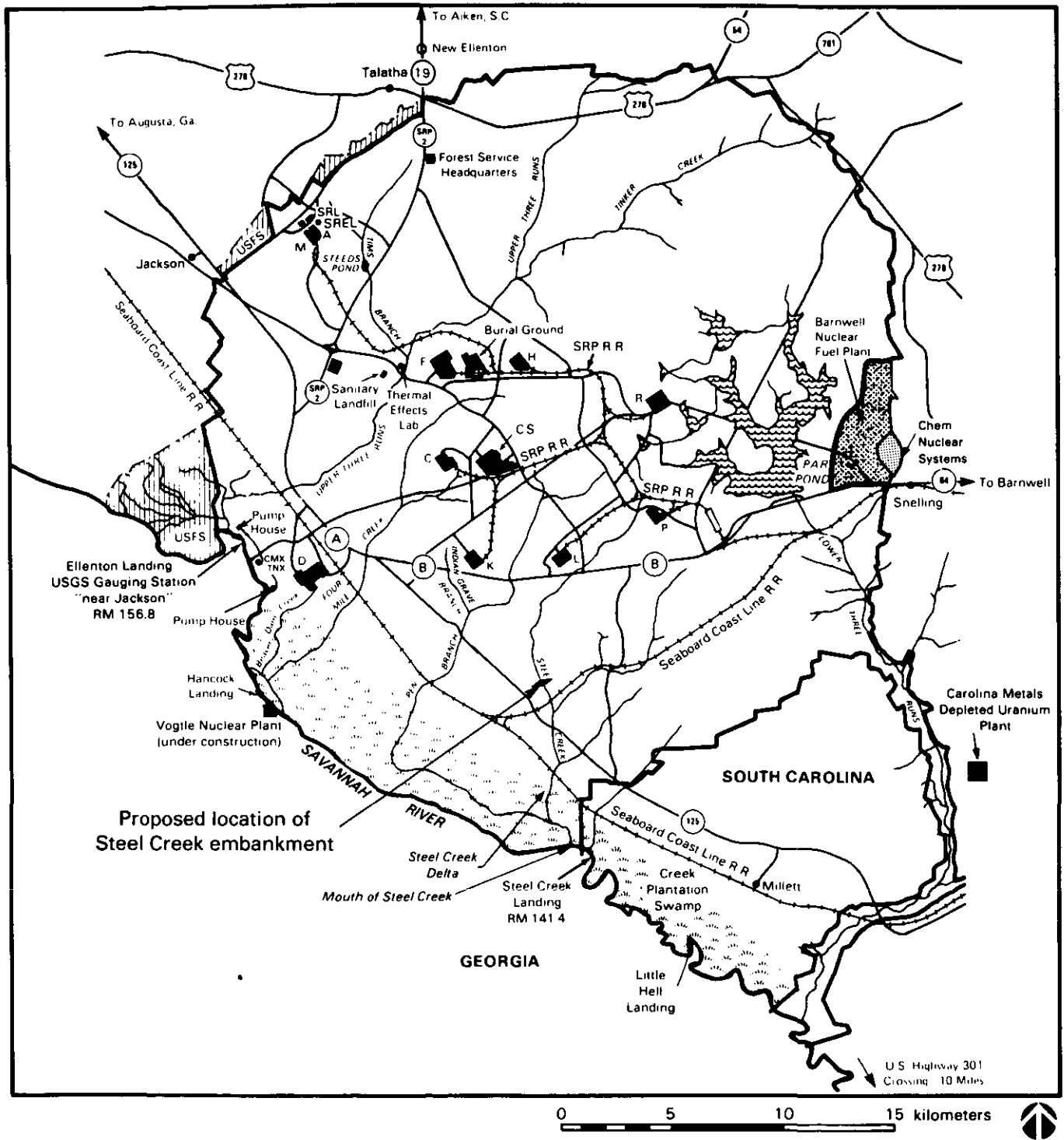


Figure L-1. Embankment location.

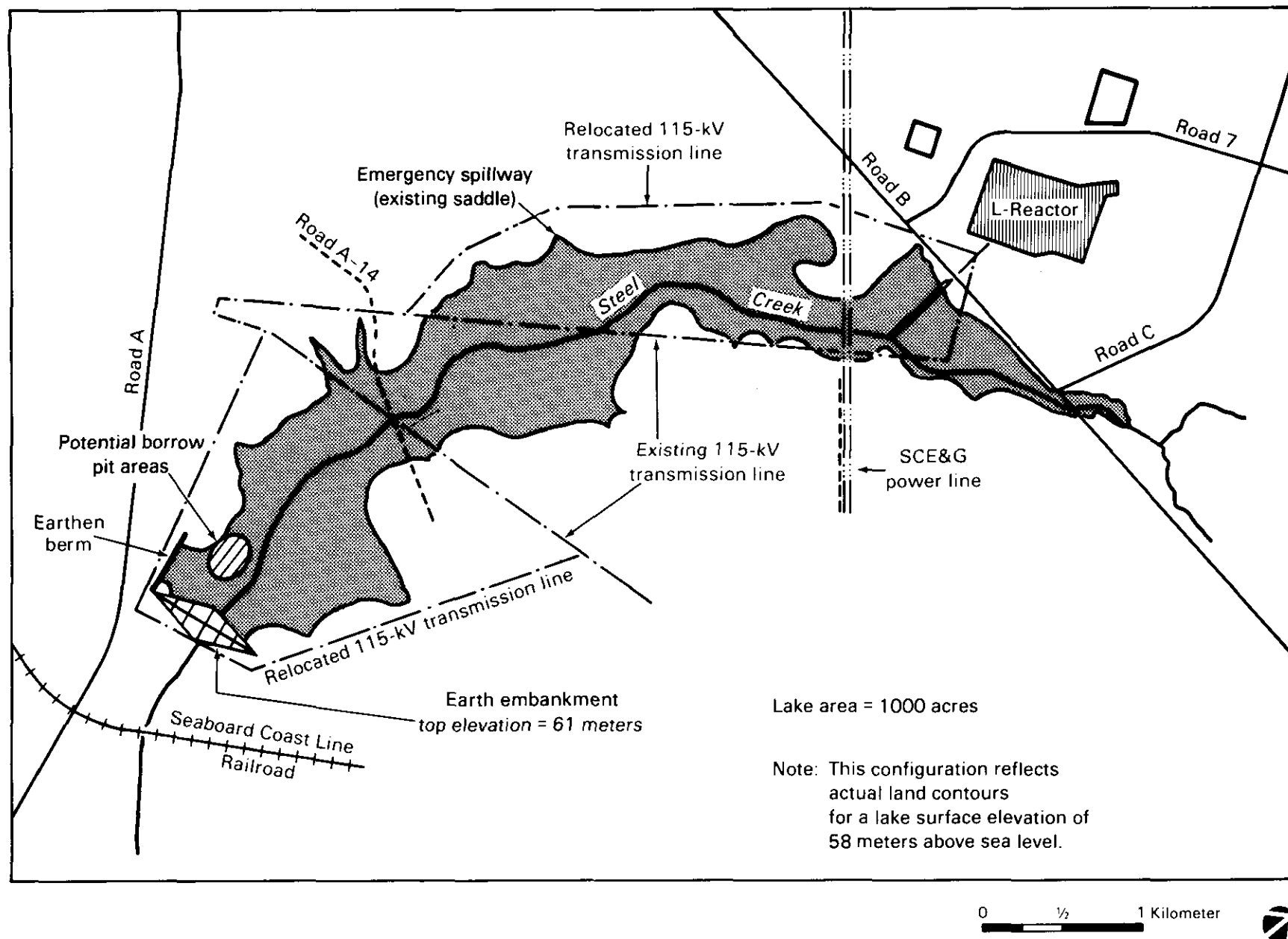


Figure L-2. Conceptual design for 1000-acre lake on Steel Creek.

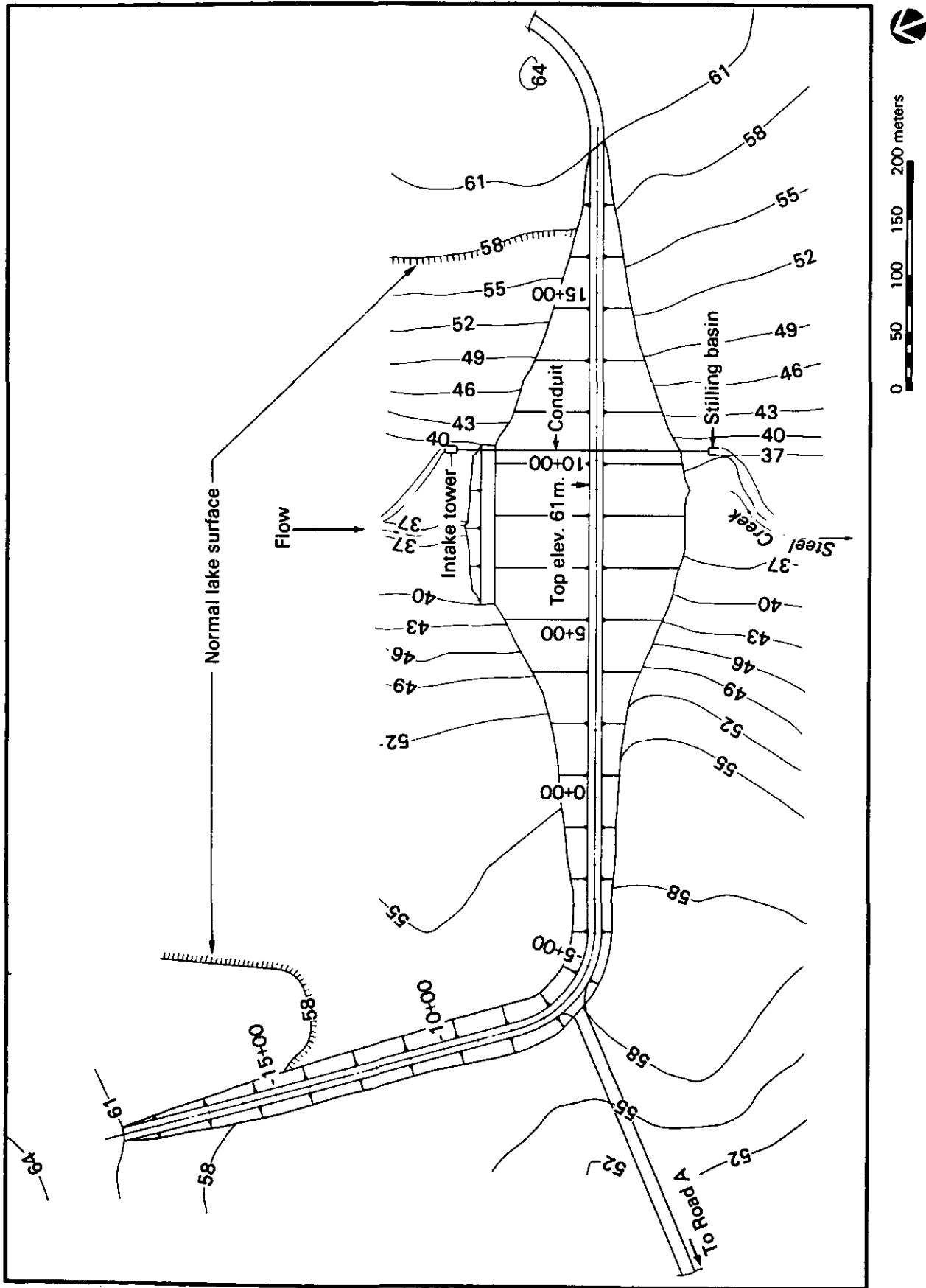


Figure L-3. Steel Creek embankment.

L.2.1.3 Relocation of existing facilities

The construction of the 1000-acre lake would require the relocation of a 115-kilovolt electric transmission line belonging to the South Carolina Electric and Gas Company (SCE&G) and two 115-kilovolt electric transmission lines and buried supervisor control and relay cable lines that serve the L- and P-Areas. The SCE&G line can be raised from existing wooden poles onto two new tall towers in its present alignment. However, the two SRP lines would have to be rerouted around the lake because of the buried cable and the width of the lake at those points. Also, two new SCE&G transmission lines presently being designed by that company will be constructed such that they will not interfere with the 1000-acre lake.

Road A-14 would be abandoned wherever it would become inundated by the lake. The access road across the embankment would begin at Road A west of the lake and be extended northeast from the east end of the embankment along a ridge to connect with Road A-14 east of the lake. This road would parallel one of the relocated SRP transmission and buried cable lines. Approximately 600 meters of Road B and 100 meters of Road C would be raised a maximum of 3 meters on their existing roadbeds at their intersection.

L.2.2 Operation

L.2.2.1 Thermal modeling

The thermal performance of the 1000-acre lake was estimated from a state-of-the-art mathematical model (Firstenberg and Fisher, 1980). The model calculates downlake temperatures for a laterally well-mixed water body (due to the long, narrow shape of the lake, total lateral mixing is a good assumption) given the shape of the lake, lake influent information (flow rate, temperature), and meteorological data (wind speed, air temperature, cloud cover, relative humidity, and time of year). The input information can be either constant or time dependent. The model has been verified by comparison with the temperature distributions of a number of operating cooling ponds.

For this analysis, 30 years of hourly meteorological data (1953-82) from Bush Field in Augusta, Georgia, were used in conjunction with monthly SRP reactor operating power levels to perform hour-by-hour simulations of lake temperature. The results of the study are described below.

L.2.2.2 Lake influent

L-Reactor will be operated at the highest allowed power level that is consistent with the maintenance of the balanced biological community in the lake, as specified in the NPDES permit that is expected to be issued by the State of South Carolina. Initially, L-Reactor will be operated to maintain 32.2°C or less in about 50 percent of the lake. Adjustments of reactor power levels will be based on near-term (several days in the future) meteorological predictions and the existing lake temperature distribution. Hourly meteorological data for the years 1953 through 1982 and the cooling-lake thermal performance model

described in Section L.2.2.1 were used in an iterative fashion to determine reactor power levels that would be required to meet the above temperature criterion. The resulting average reactor power reduction was approximately 7 percent. For the life-cycle cost comparison in Section L.1, the average power reduction was increased to 14 percent to provide a sufficient margin in relation to the temperature criterion, due to the fact that reactor power levels will be based on predictive meteorology, and in recognition of the fact that frequent reactor power changes would also be restricted by considerations other than the thermal criterion.

L.2.2.3 Lake temperatures

As indicated in Section L.2.2.2, the plant will be operated in a manner such that the temperature of the water covering about 50 percent of the lake would not be greater than 32.2°C. Although the exact operating mode of the plant will depend on production schedules and meteorological conditions, the lake performance based on power levels determined in the iterative method discussed in the previous section will be used to represent the expected monthly temperature distributions in the lake. Figures L-4 through L-7 indicate the percentage of the lake surface area having a given temperature for each season of the year. (Note: In this analysis, winter is defined as December, January, and February; spring is March, April, and May; summer is June, July, and August; and fall is September, October, and November.) As can be seen from these figures, the water temperature of the coolest 50 percent of the lake ranges from 23° to 17°C in winter (with some months of the 30-year data base implying temperatures as low as 20°C to 14°C) and 32° to 31°C in summer.

Figures L-8 through L-11 show the estimated isotherms in the 1000-acre lake at a depth of approximately 1 to 2 meters. The shaded areas represent areas in the lake that will be below 32.2°C for each season, after accounting for reduced reactor operating power. An auxiliary flow model was used in conjunction with the lake temperature graphs presented in Figures L-4 through L-7 to derive these isotherm shapes. The actual distribution of lake water temperatures will vary from the isotherm representation shown in Figures L-8 through L-11. This variation will occur because of transient wind effects and water density differences.

The heated water being discharged into the lake would spread over the cooler water residing in the lake. This surface layer would tend to exist throughout most of the lake due to the relatively small advective transport of the discharge, the depth of the lake, and the large temperature difference (between the influent and the effluent) within the lake. In addition, the discharge into the lake would be accomplished so that mixing of the discharge and resident lake water would be kept low (a desirable condition to maximize the heat flux through the water surface). Based on observations in Par Pond, as well as theoretical considerations, the surface layer in the L-Reactor cooling lake is expected to be a few feet thick. This layer would be vertically well mixed due to wind-induced turbulence. A cooler sublayer would exist beneath the surface layer. This layer would be fed by lake water returning from the cold end to satisfy the continuity requirements of discharge mixing and lake withdrawal. Accordingly, the temperatures in the deeper portions of the lake would approximate the cold end temperatures. That is, the colder sublayer temperature

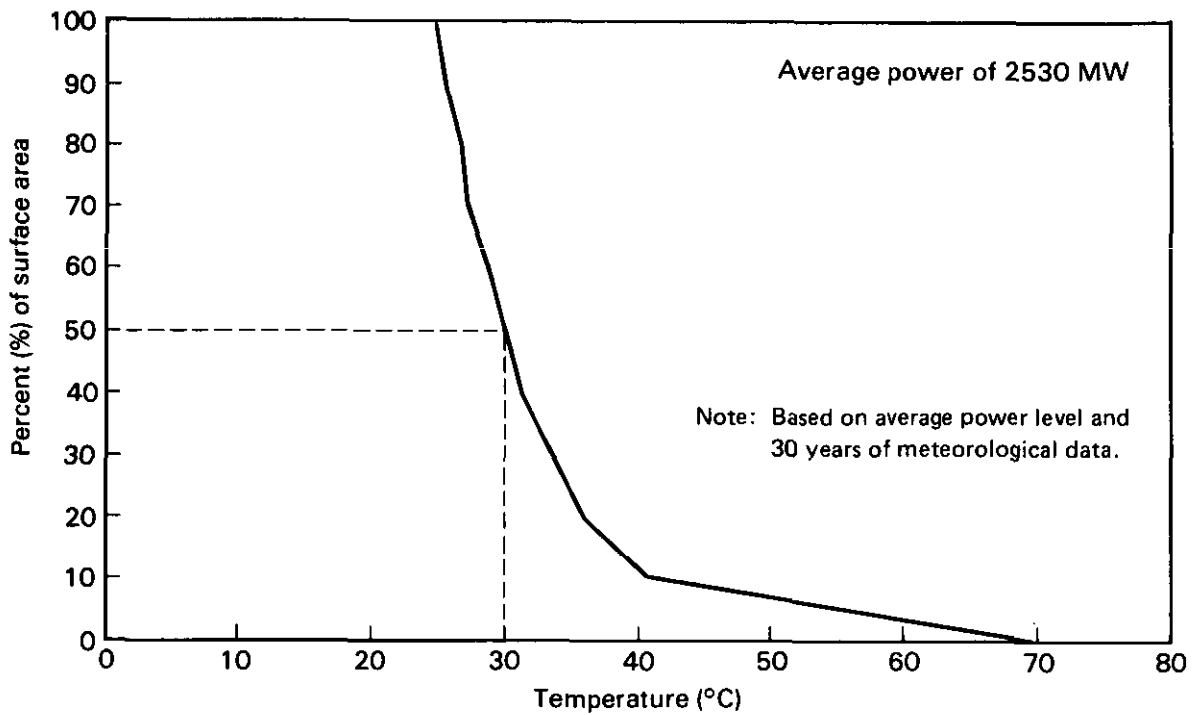


Figure L-4. Percent of lake surface with the temperature greater than indicated (spring).

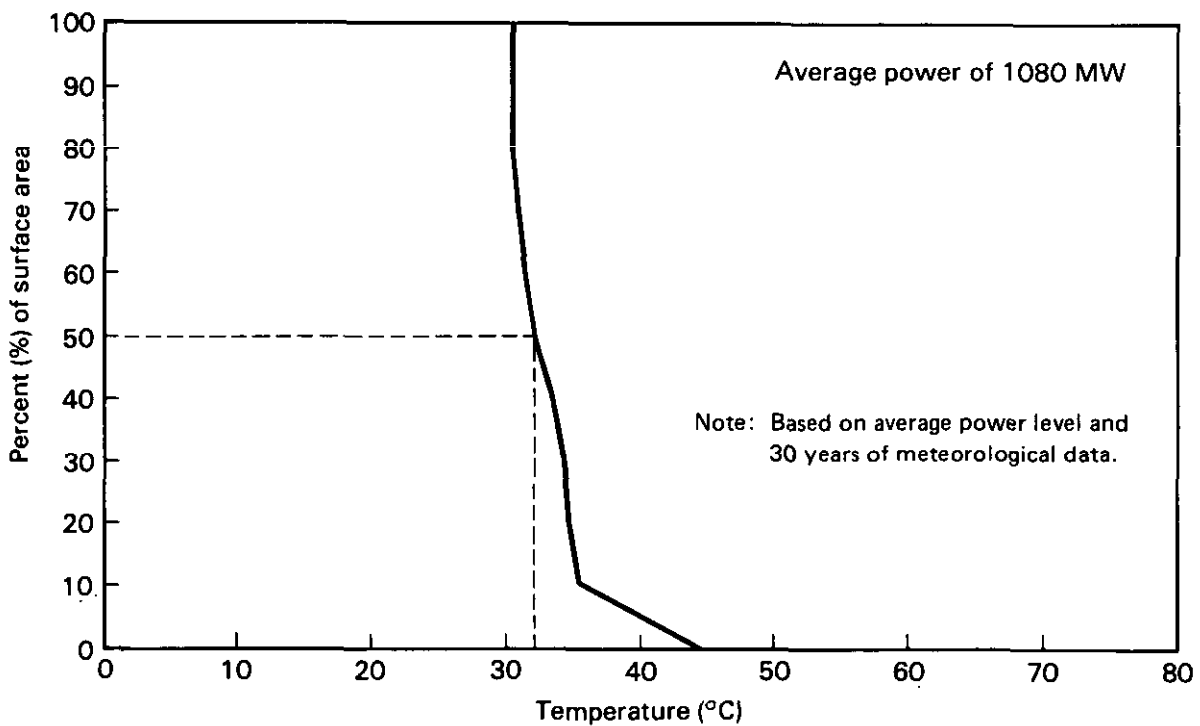


Figure L-5. Percent of lake surface with the temperature greater than indicated (summer).

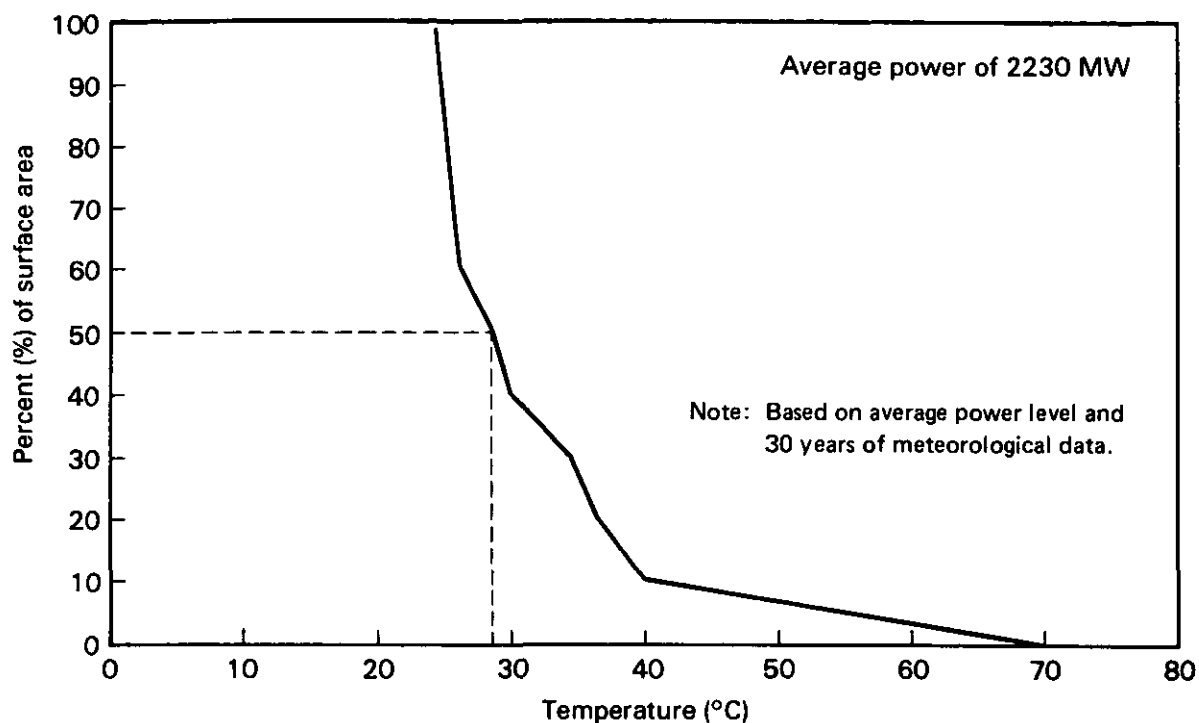


Figure L-6. Percent of lake surface with the temperature greater than indicated (fall).

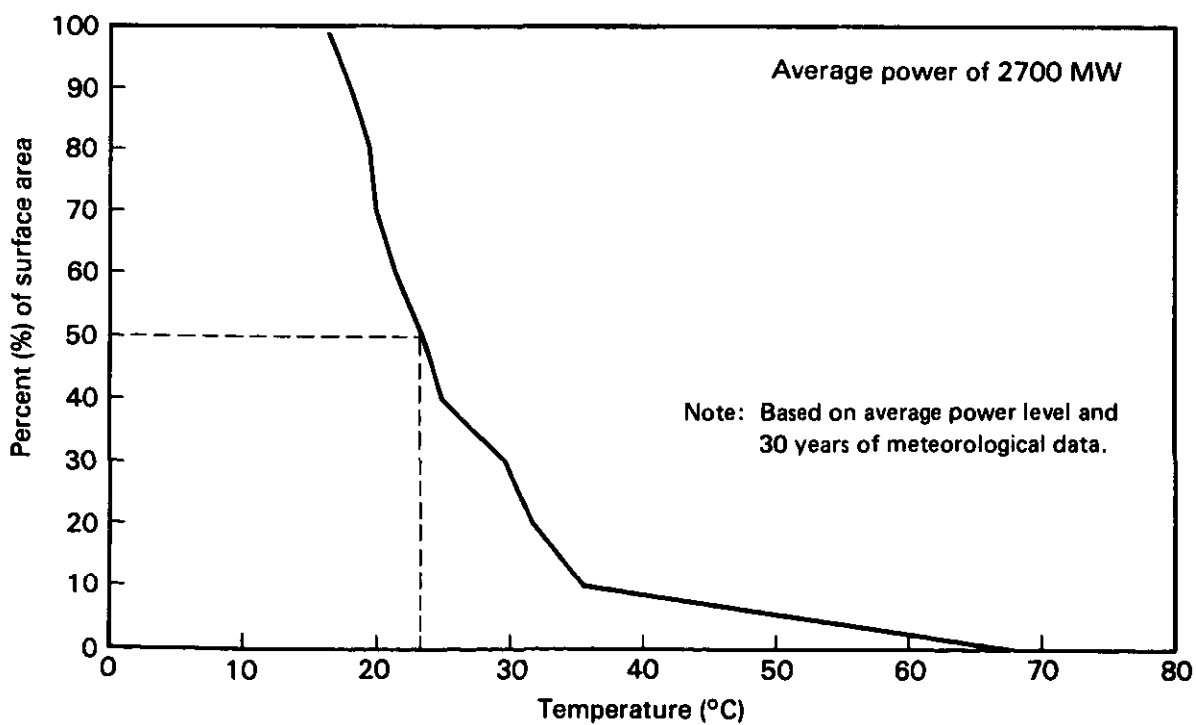


Figure L-7. Percent of lake surface with the temperature greater than indicated (winter).

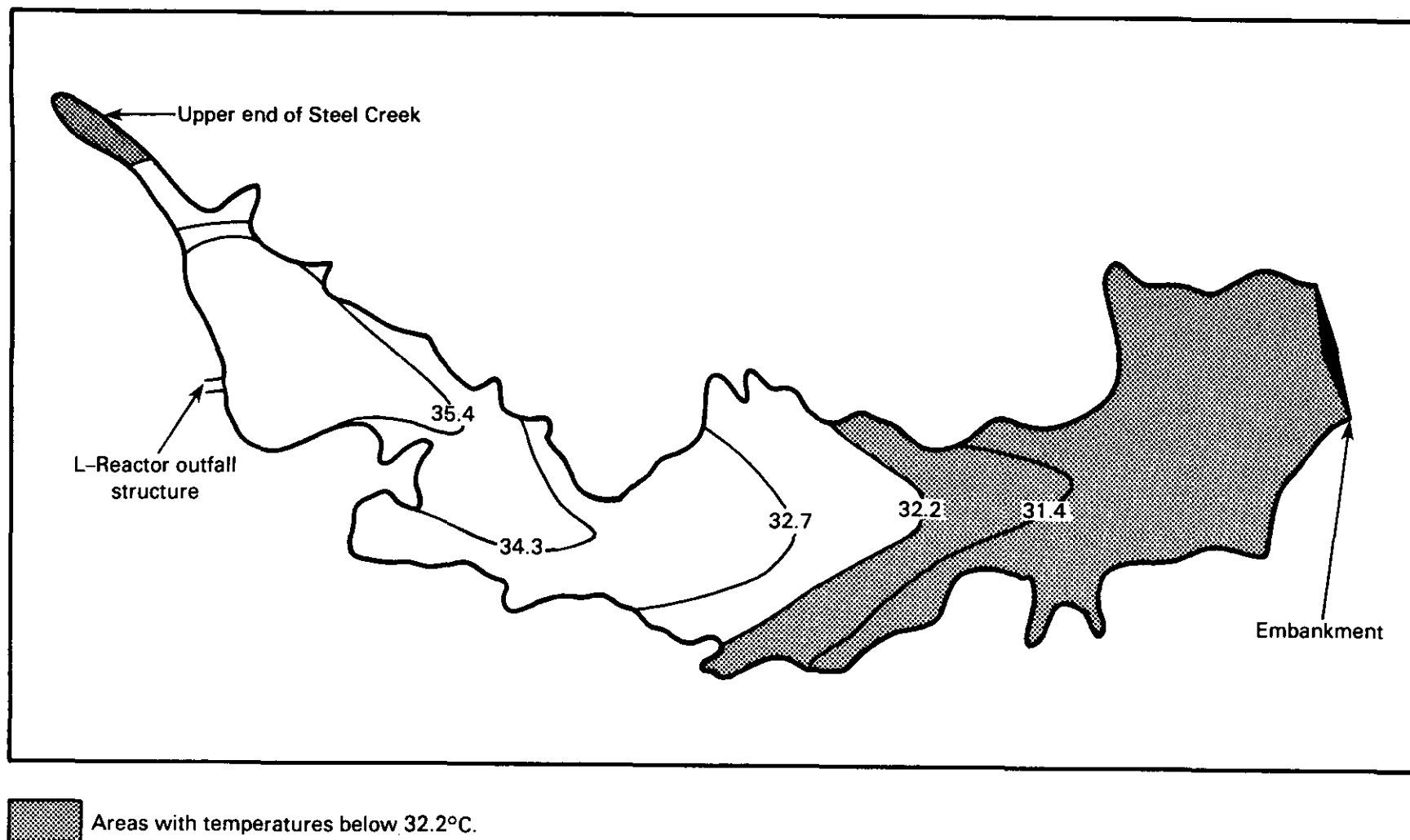


Figure L-8. Estimated isotherms for the 1000-acre lake (summer).

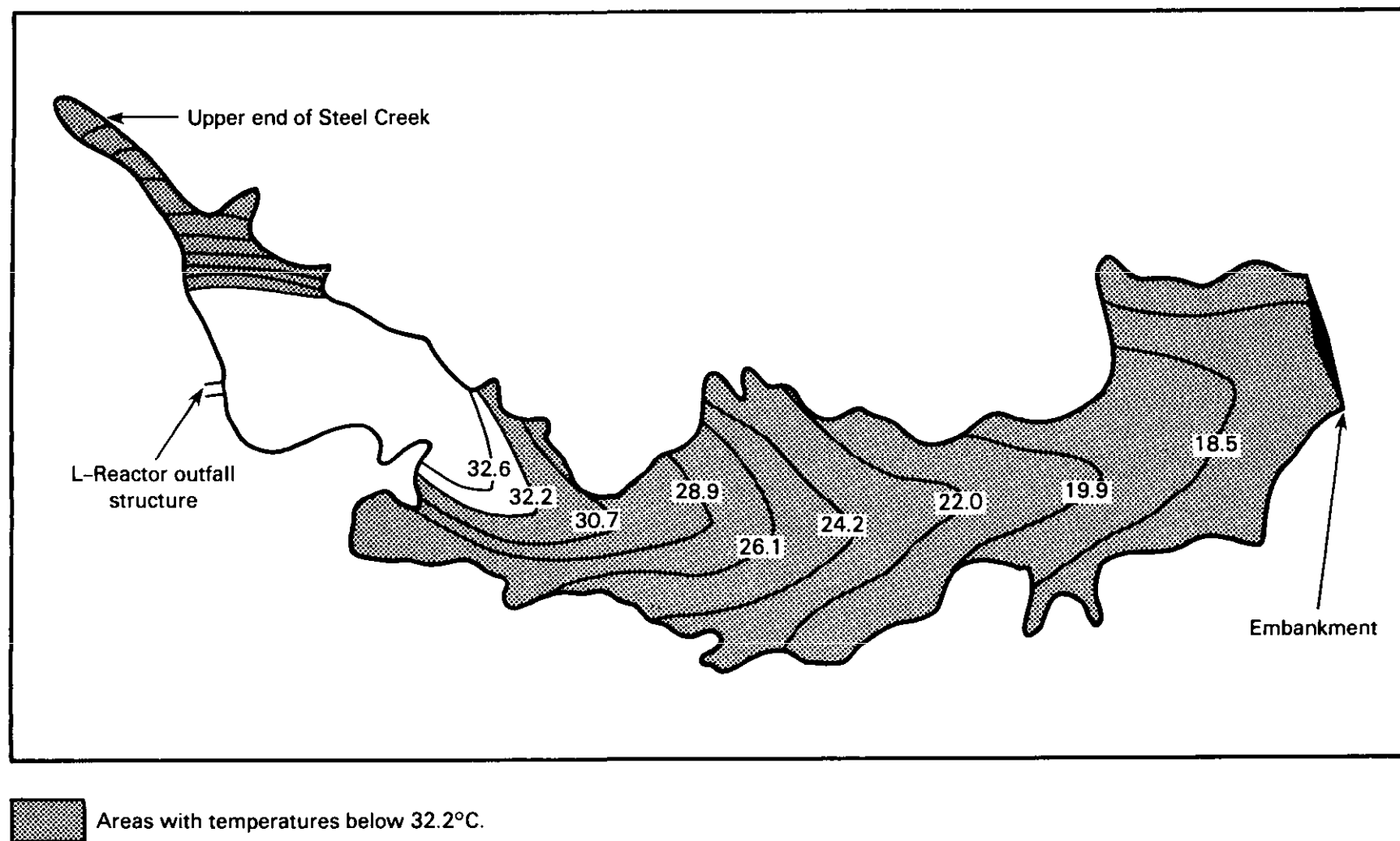


Figure L-9. Estimated isotherms for the 1000-acre lake (winter).

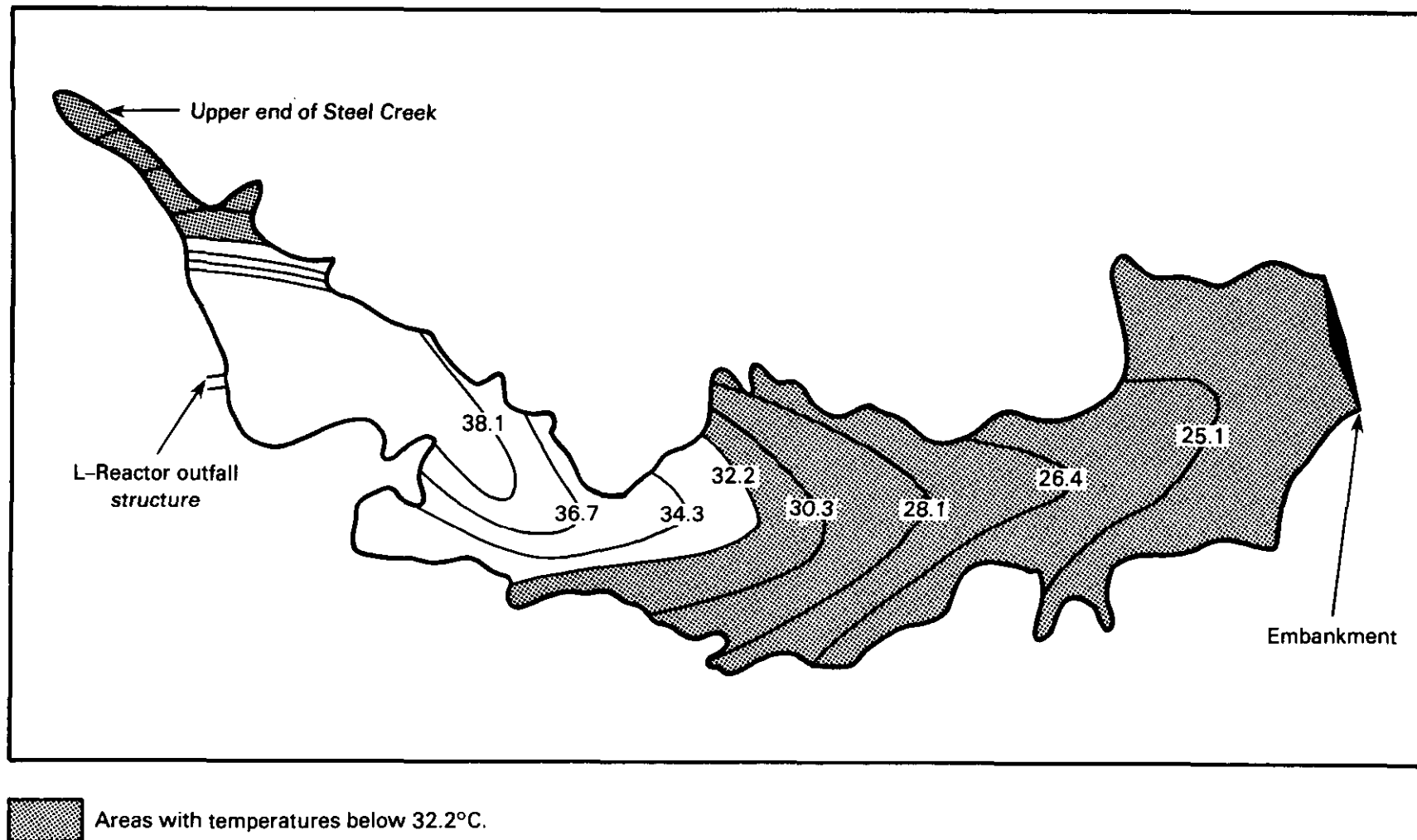


Figure L-10. Estimated isotherms for the 1000-acre lake (fall).

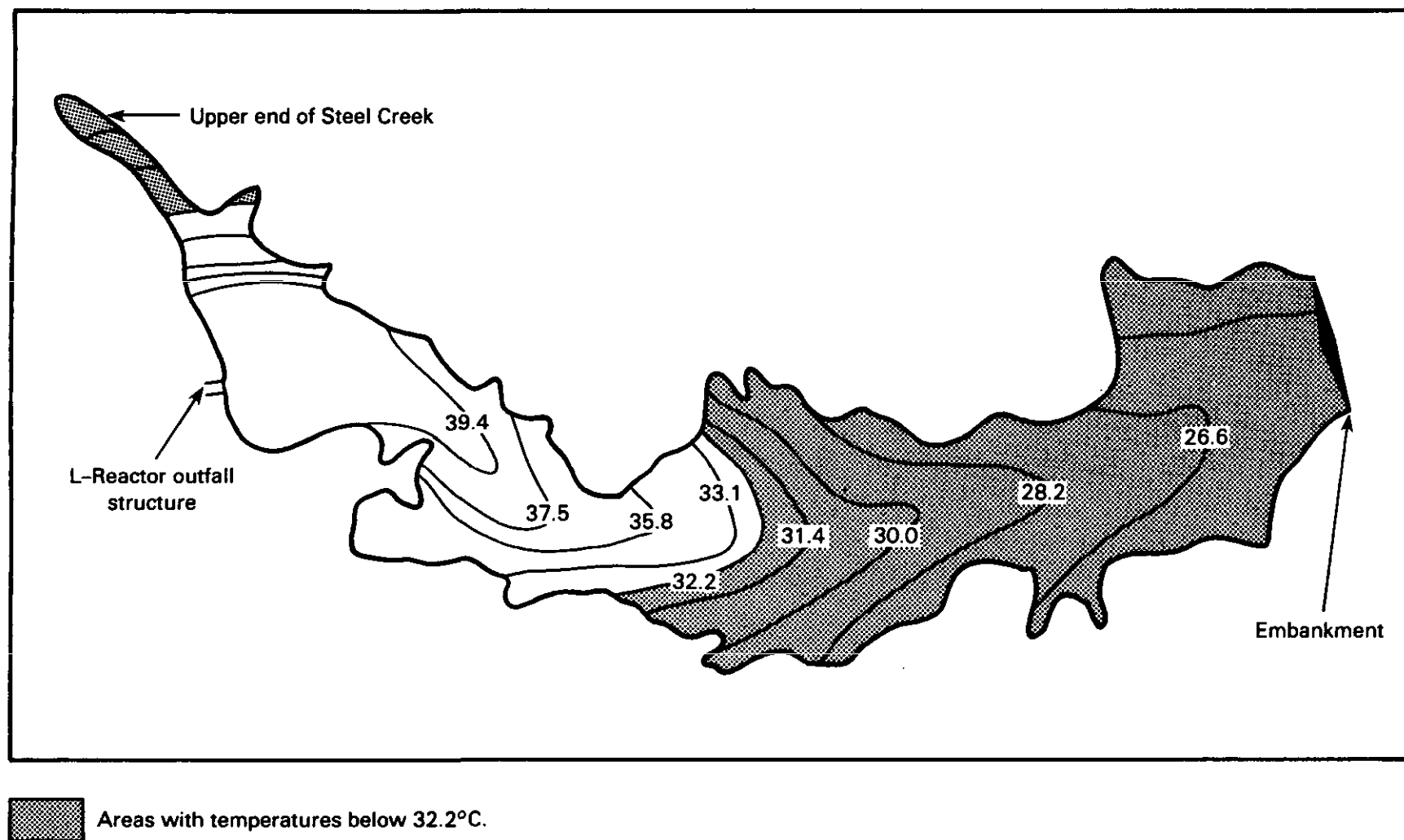


Figure L-11. Estimated isotherms for the 1000-acre lake (spring).

would range between approximately 17° and 31°C throughout the year (although some winter temperatures might be as low as 14°C, as inferred from the 30-year data base).

L.2.2.4 Lake operation

During construction of the embankment, streamflow would be carried through the work area in a temporary metal conduit laid parallel to the outlet works conduit. An upstream cofferdam, with a crest at elevation 43 meters above mean sea level, would divert the water into the metal conduit and protect the work site. A low downstream cofferdam would protect the site from rising tailwater. This diversion configuration would provide protection from a storm with a recurrence interval of between 25 and 50 years.

Following completion of the reconfigured discharge canal, outlet works and embankment, the outlet gates would be closed and the pool elevation of the lake would be allowed to rise to the design elevation of 58 meters above mean sea level. Assuming a constant inflow of about 11 cubic meters per second of Savannah River water from L-Reactor, 0.45 cubic meter per second from P-Reactor, and 0.62 cubic meter per second Steel Creek base flow, approximately 30 days would be required to fill the lake. As impoundment of the lake occurred, the response of the embankment would be monitored to verify design. Flow would be maintained down Steel Creek below the embankment during filling. Lake filling would be completed before startup of L-Reactor.

Cooling water and lake discharge flows would be managed to maintain a balanced biological community in the lake and in Steel Creek and swamp. Reactor cooling-water flow variations and lake discharge management would restrict water level fluctuations to assure a healthy aquatic macrophyte population in the lake. The development of shoreline refuge areas also would enhance this macrophyte population, which would provide the necessary habitat for growth and reproduction of certain fish and macroinvertebrates necessary to maintain a balanced biological community (see Section L.4.1.1.2).

Downstream flows would be maintained constant throughout reactor operating periods, except during periods of extreme rainfall. During short reactor outages occurring within the spring spawning period, the flow at Road A would be controlled to about 3 cubic meters per second, thereby maintaining good spawning habitat. The remainder of the year, flow in Steel Creek at Road A during shutdown periods would maintained at about 1.5 cubic meters per second, providing opportunities for fish to move freely from the base of the embankment to the Savannah River Swamp.

If long reactor outages should occur during the spawning period, flow would be maintained at a rate of about 3 cubic meters per second. For long outages at other times, only base flow conditions would occur in Steel Creek.

L.2.3 Design bases

L.2.3.1 Design flood

The embankment and its outlet works would be designed for the U.S. Army Corps of Engineers' "Standard Project Flood." The Standard Project Flood is the flood that can be expected from the most severe combination of meteorologic and hydrologic conditions that are considered reasonably characteristic of the region. It was established by the Corps of Engineers as a practicable expression of the degree of flood control works for situations that involve the protection of human life and high-value property.

Because the Standard Project Flood is developed from extreme hypothetical conditions, it cannot be assigned a specific recurrence interval. [A recurrence interval is defined as the average interval in years between the occurrence of a flood of specified magnitude and an equal or more severe flood (Linsley and Franzini, 1979).] A recurrence interval of a few hundred to a few thousand years is commonly associated with the Standard Project Flood.

At the site, the Standard Project Flood is a 96-hour storm of varying intensity that produces a total rainfall of 51 centimeters. Figure L-12 compares this storm with the precipitation-frequency characteristics of the area. The figure shows the maximum depth of rainfall for various durations and recurrence intervals. The maximum depth of rainfall for the design storm is superimposed on this. The design storm exceeds the 100-year storm for all durations. The dotted lines are extrapolations of the published precipitation-frequency data. They provide an indication of the design storm's recurrence interval for various durations. For example, the 96-hour duration, 51-centimeter depth corresponds to a recurrence interval of more than 10,000 years. The response time of the 1000-acre lake's watershed is such that durations in the 2- to 6-hour range are the most significant. In this range, the storm's recurrence interval varies from about 1000 to 40,000 years. Section L.3.4.1.3 describes the results of the computer analysis of the Standard Project Flood on Steel Creek.

An even rarer flood, the probable maximum flood (PMF), was also included in the design bases. This flood is the result of a 72-centimeter rainfall in 24 hours. The principal outlet works and existing natural emergency spillway (see Section L.2.3.3) are capable of controlling the PMF.

L.2.3.2 Seismic analyses

Seismic considerations would be included in the design of the foundation, embankment, and outlet works. Sand and gravel filters would be installed to dissipate pore pressures and heal possible cracking resulting from a seismic event. To reduce the effect of seismic-induced deformation, the embankment design would incorporate a wide crest, intermediate berm, and flat slopes. Analysis of the liquefaction potential of the foundation would be evaluated for any needed improvements. Detailed seismic analyses have not been performed, but the embankment design will include appropriate seismic considerations. The consequences of the unlikely event of embankment failure are discussed in Section L.4.2.2.

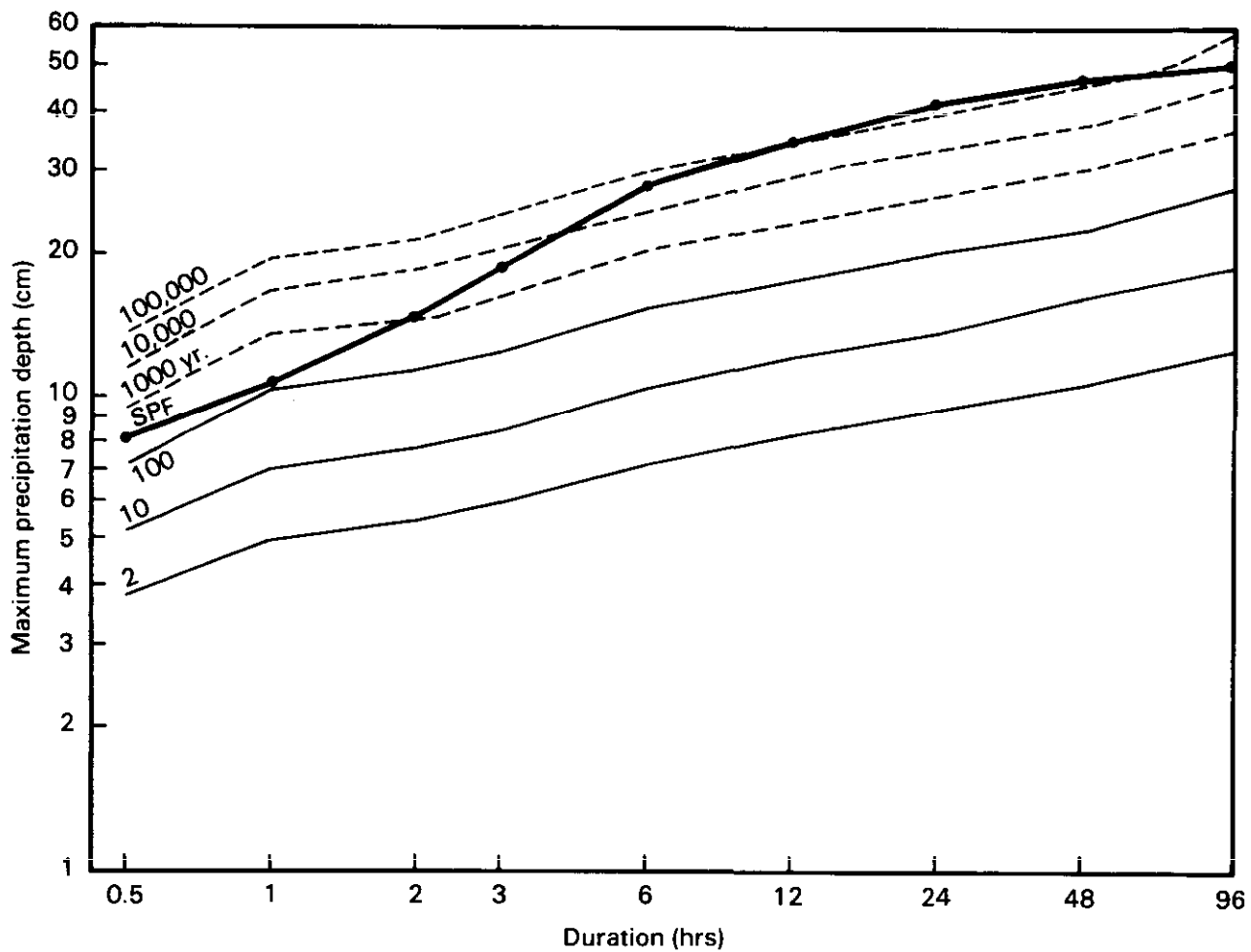


Figure L-12. Standard project flood related to site depth-duration-frequency.

L.2.3.3 Other design criteria

The outlet works would consist of a vertical intake tower with multilevel gates, a concrete conduit, and a stilling basin. These works would be designed to pass the L-Reactor cooling-water flow, the service-water flow from P-Reactor, and the natural base flow, while holding the lake elevation at 58 meters above mean sea level. They would also serve as the principal flood-control outlet designed to be fully capable of controlling the standard project flood.

In the extremely unlikely event of a flood that is more severe than the standard project flood, overtopping of the embankment would not occur. A natural saddle would serve as an emergency spillway and divert flow to Pen Branch. This saddle has an elevation of about 60 meters at its low point and spans 183 meters at the top of the embankment elevation of 61 meters. The probable maximum flood (PMF) would result in a maximum pool elevation between the low point of the saddle and the top of the embankment. Section L.3.4.1.3 describes the results of the computer analysis of the PMF on Steel Creek.

L.2.4 Construction

L.2.4.1 Relocation of existing facilities

SCE&G would design and relocate its own transmission lines. The design and construction of the relocation of the SRP roads and transmission and control cable lines would be performed by the Du Pont Engineering Department. The U.S. Forest Service would administer all clearing for these relocations as well as for the lake area.

L.2.4.2 Site preparation

L.2.4.2.1 Clearing

All areas upstream from the embankment and less than 58 meters above mean sea level would be cleared of second growth pine and hardwood to provide for the 1000-acre lake area. All marketable timber from this area and from the road and transmission corridors would be cut, removed, and sold under the supervision of the U.S. Forest Service. Timber and vegetation in any area flooded by Steel Creek waters since 1954 might contain low-level radioactivity and would not be marketable. Procedures for the removal and disposition of such material would be developed and approved before construction started. Underbrush and scrap from timber cutting outside the area flooded by Steel Creek since 1954 except around some of the shoreline area would be piled and burned. Stumps would be removed under all embankment areas but not from the area within the lake.

L.2.4.2.2 Foundation preparation

Areas to be covered by the embankment, inlet and outlet works, or roadways would be grubbed and stumps would be removed and burned. All topsoil would be

stripped and stockpiled for use on the finished grade for turf establishment. It could be necessary to excavate unconsolidated sediments from the area under the dam to a depth of between 3 and 15 meters to expose a tight clay formation to which the embankment could be sealed. Approximately 600,000 cubic meters of unsuitable material could be removed from the embankment site before 1.2 million cubic meters of borrow fill and rip-rap would be placed to form the embankment. Spoil from the surface portion of the embankment foundation in the Steel Creek floodplain, estimated to contain a total of 0.2 curie of cesium-137 and 0.02 curie of cobalt-60, would be separated, contained, replaced outside the jurisdictional wetlands upstream of the embankment, and covered with subsurface spoil to prevent erosion during the construction period. ["Jurisdictional wetlands" are those areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 323.2c).] This relocation would have no effect on net cesium transport estimates. All other material would be removed and used for backfill in the borrow areas.

L.2.4.2.3 Abandoned well survey and sealing

Research is currently underway to determine how many wells were constructed within the lake area before Government acquisition of the SRP property. All of these wells would be sealed before the lake begins filling to reduce the chance of affecting ground-water quality.

In March 1984, a survey team from the Furman University Department of Geology performed a field survey of this portion of the Steel Creek watershed. Twenty old possible well sites were identified in this area, 11 of which were found to lie within the boundaries of the 1000-acre lake. The sites vary from shallow open depressions to deep-cased and screened wells. Several of these might be grave sites or archeological sites rather than wells.

Each site identified, as well as any others drilled or located during construction of the 1000-acre lake, would be sealed by filling from bottom to top with sand-cement or concrete in accordance with the South Carolina Primary Drinking Water Regulations, Section R-61-58.2 C (14) "Permanent Well and Test Hole Abandonment." All information relative to each site (e.g., exact plant coordinate location, depth, diameter) would be recorded and submitted to SCDHEC.

L.2.4.3 Earthwork and other civil construction

L.2.4.3.1 Embankment construction

The embankment would be of rolled earth construction, excavated from borrow areas nearby or within the lake area, and transported with standard earth-moving equipment. The interior of the embankment would be divided into impervious zones and drainage zones to provide internal and foundation drainage, relieve pore pressures, and heal possible cracking resulting from a seismic event. Piezometers would be installed during construction and permanent instrumentation to monitor embankment performance would be included as part of the design.

The design would limit the embankment slopes from 3 to 4 meters horizontally for each meter of height (Figure L-13). Flat berms might be required on both faces partway up the slopes. The exposed portion of the upstream slope would be protected against erosion caused by variations in water level and wave action by rip-rap on a gravel filter bedding.

Criteria of embankment stability design have established that seepage of water is a critical consideration. Therefore, the embankment will be designed so that total permanent seepage loss through the embankment abutments and foundation will be limited. To ensure positive restriction through the foundation of the embankment, an impervious soil or grout cutoff trench will be constructed to the maximum depth that is economically feasible and tied into the abutments. Seepage through the embankment will be slight, because the embankment will consist of three or four zones.

L.2.4.3.2 Roadway and utility access

An access road would be constructed from Road A approximately 400 meters to the west end of the embankment. This road would become the permanent access to the completed facility for operation and maintenance. Another road would be constructed from Road A-14 east of Steel Creek southwesterly along a ridge to the east end of the embankment. This road would provide a route from the railroad siding at Meyers Mill to the embankment site.

An electric transmission line would run southeasterly approximately 1500 meters from an existing substation near Roads A and A-16. This line would provide 120/208/460-volt electrical power service for lighting, instrumentation, and gate motors. A small building would be required at the embankment to house instruments and controls.

L.2.4.3.3 Borrow pit operation

Areas close to the embankment would provide the approximately 1.2 million cubic meters of borrow material necessary to construct the embankment. This material must meet the specifications for the various zones contemplated. Any borrow area outside the limit of the lake would have to be cleared and then regraded; ground cover would have to be established after the borrow material had been removed. Therefore, primary consideration would be given to finding suitable material within the area to be cleared for the lake. By excavating areas at or just above the normal pool elevation, the surface area of the lake could be increased at little additional cost. Some internal drainage material and all riprap material would be brought to the construction site from outside SRP.

L.2.4.3.4 Outlet works

The outlet works would consist of a freestanding intake tower with multilevel gates, a concrete conduit and a stilling basin (Figure L-13). The vertical intake tower would be a cast-in-place concrete structure consisting of a flood control passage and two collection wells. A concrete conduit would be used to carry water from the intake tower through the embankment. This conduit would also carry the normal releases from the lake. The outlet works would be fully capable of controlling floods with a recurrence interval of greater than 100 years.

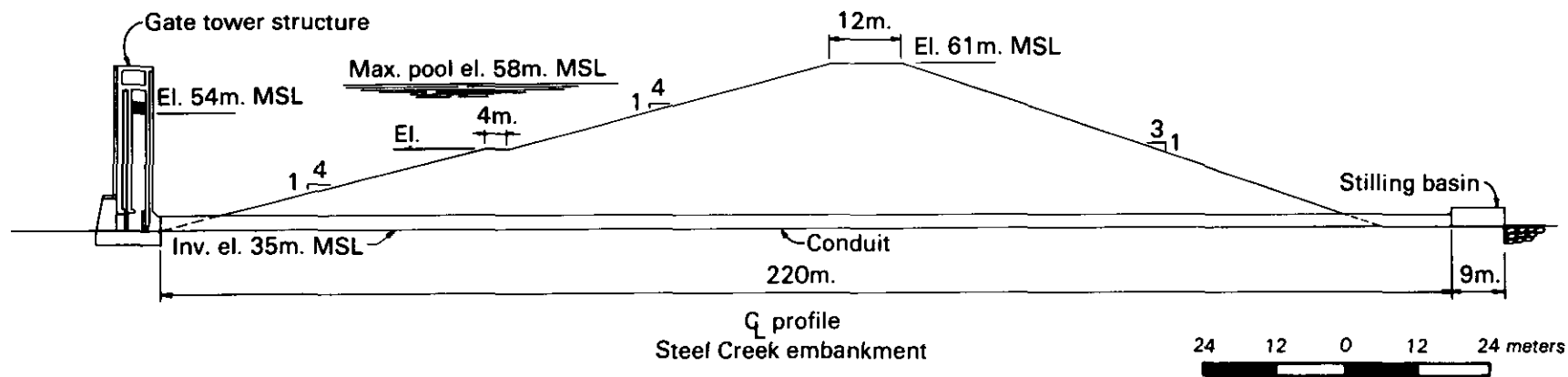


Figure L-13. Steel Creek embankment.

Four to six gates would be installed in the intake tower. One multilevel intake gate would be located in each of two opposing walls of the intake. The invert elevation of these gates would be 54 meters MSL. The two gates would pass about 11.3 cubic meters per second, the normal flow, and be operated in a totally open or totally closed position. Water could enter the discharge structure at a depth of 2 to 4 meters below the surface and/or from near the bottom of the lake. Discharge would be regulated with a service gate located at the bottom of each collection well at the tower invert (at 35 meters elevation). An emergency gate would be located upstream of each service gate to provide a positive cutoff should the service gate fail. A trash rack would be located upstream of the emergency gates to prevent debris from interfering with the operation of the service gates. The gates would be electrically controlled from the service building; provisions would be made for emergency manual operation of the gate.

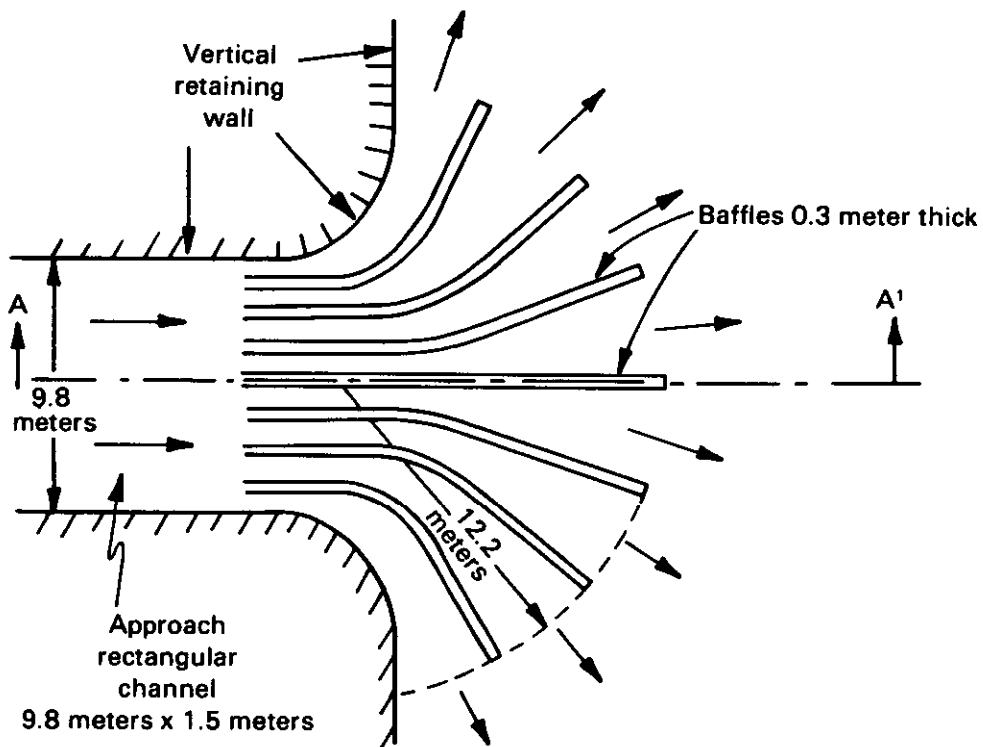
L.2.4.4 Reconfiguration of outfall canal

The existing outfall canal would be completely submerged by the 1000-acre lake, which would have a normal pool elevation of 58 meters above mean sea level. The existing 1.8-meter-diameter discharge pipe has a bottom elevation of 58.5 meters and drops vertically at a concrete headwall to an existing concrete stilling basin at the head of the outfall canal, which has a bottom elevation of 53.3 meters. Therefore some reconfiguration must be accomplished to reduce the 4.3-meters-per-second velocity and 1.8-meter height of the cooling-water flow where it would leave the pipe and enter the lake. Cooling efficiency of the lake would be enhanced by distributing the heated water over as large an area of the lake surface as possible without mixing it with the lower depths of the lake volume.

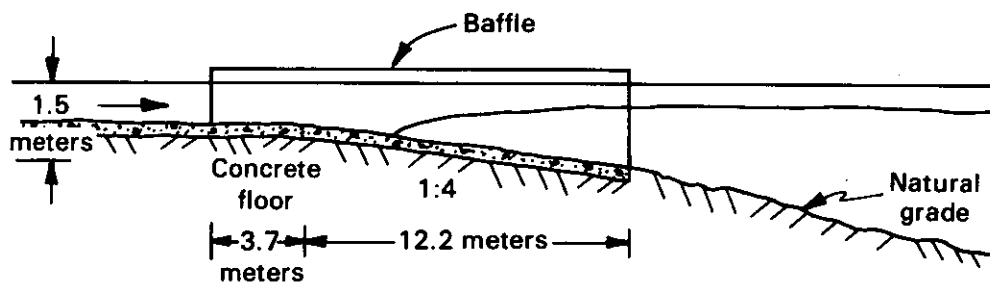
The design for the most appropriate method for reducing the velocity and distributing the heated effluent over the lake surface would be based on detailed engineering studies. Figure L-14 is an example of one possible configuration. Such a radial discharge design, consisting of radial baffles, would spread the flow momentum uniformly in all horizontal directions, thereby reducing eddying effects. With a properly engineered design, it could be possible to minimize the vertical entrance mixing by creating a stable interface and strongly reducing and horizontal circulations in the vicinity of the discharge.

L.2.4.5 Schedule

It was determined that with close coordination and cooperation between DOE and the Corps of Engineers, an expedited schedule could be met. Under the schedule, construction of the 1000-acre lake could be completed in 6 months. This expedited schedule would be possible because the Corps of Engineers has an experienced staff available to design and construct the embankment that would form the lake; this staff is available because it is now completing the construction of the Richard B. Russell Dam on the Savannah River. In addition, the construction does not depend on the procurement of long-lead-time items (i.e., the special-order pumps required for recirculating cooling towers).



A. Radial discharge design



B. Cross-section A-A

Figure L-14. Reconfigured outfall canal (top) and cross-section of proposed new canal structure (bottom).

L.2.4.6 Resource Requirements

L.2.4.6.1 Manpower

Approximately 550 workers would be required to construct the 1000-acre lake. These workers would include about 30 civil engineers for design and construction supervision, but would not include current DOE and Du Pont employees who would provide liaison to the construction managers.

Because most of the work in this alternative would be standard civil construction activities such as clearing, earthwork, and the building of minor concrete structures, and because the design includes few mechanical or electrical items, local labor should be able to sustain the level of effort necessary to complete this alternative in a timely manner.

L.2.4.6.2 Cost

Capital cost of the project is estimated to be approximately \$25 million, with an annual operating cost of \$3.4 million. The present worth would be \$111 million, and the annualized cost would be \$13.1 million.

L.2.4.7 Construction impacts

L.2.4.7.1 Historic/archeological

Four historic sites and one prehistoric site in the Steel Creek terrace and floodplain system have been determined to be eligible for inclusion in the National Register of Historic Places. No direct impacts are expected to the prehistoric site or to three of the historic sites because they would be below the embankment and outside the area affected by high-water flow conditions. One historic site area would be inundated when the lake was filled. These sites are shown on Figure L-15. These impacts would be mitigated as described in Section L.2.4.8.1.

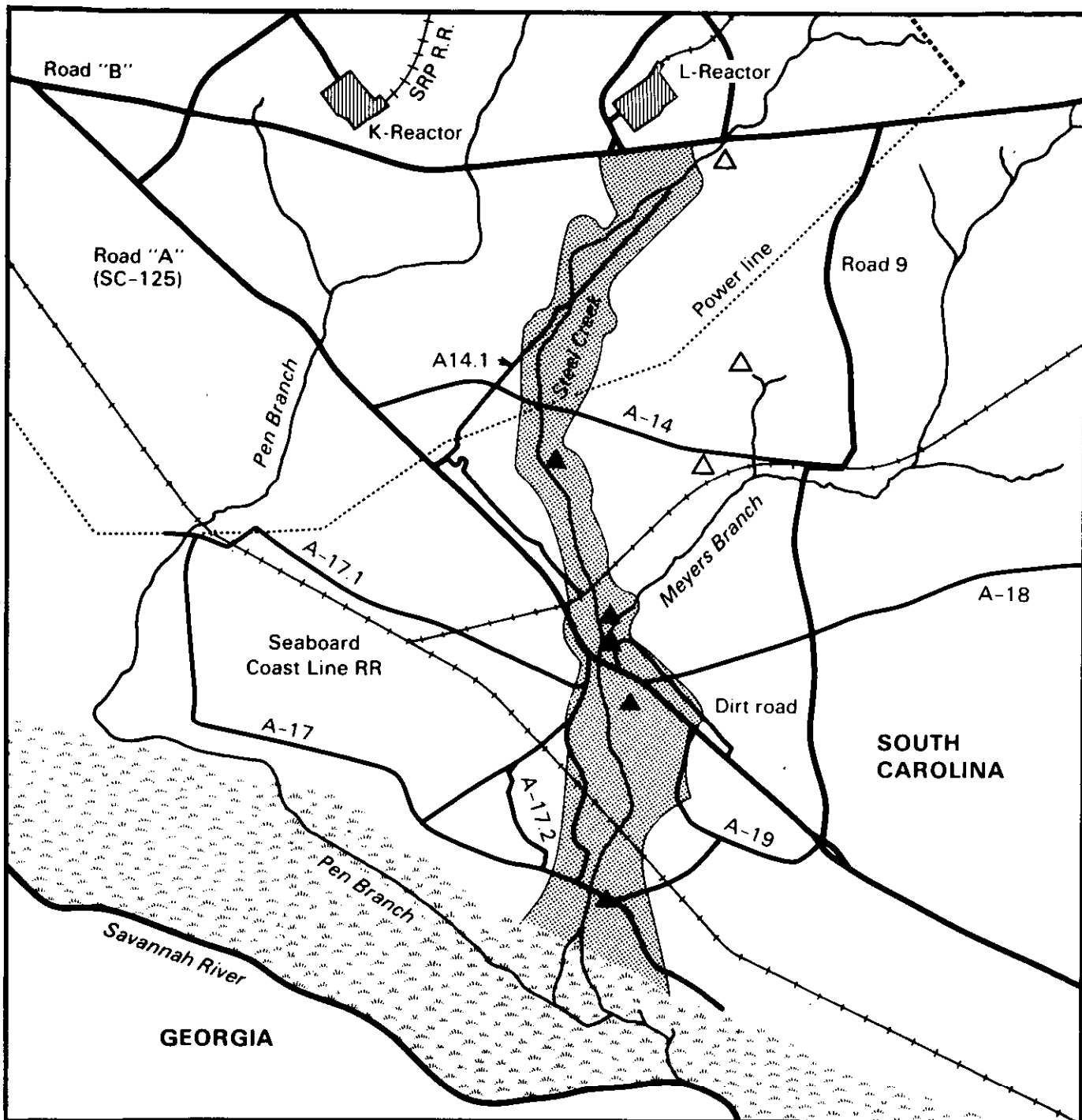
In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register of Historic Places.

L.2.4.7.2 Ecology

There would be two principal sources of potential impact to the ecology of the area: (1) the construction of the embankment and associated appurtenances, and (2) the inundation by the lake.

L.2.4.7.2.1 Embankment construction

The construction of the earthen embankment and water diversion system for the lake would cause some temporary increases in suspended solids in Steel Creek. Suitable precautions would be taken (1) during the construction operations necessary to establish a foundation for the embankment, and (2) during



Legend:

-  Swamp
-  Area intensively surveyed
-  Archeological/historic sites (Hanson et al., 1981)
-  Archeological/historic sites (Brooks, 1984)

Figure L-15. General map of archeological survey area and sites listed in the *National Register of Historic Places*.

emplacement of the fill to ensure that undue silt and debris loads do not move downstream from the construction site. Turbidity screens could minimize impacts to downstream areas.

Borrow pits for similar quantities of suitable materials have been identified in the past for construction at the Savannah River Plant, and have been controlled in an environmentally acceptable manner. About 90 percent of the fill material for the embankment would probably come from a borrow pit that would be submerged when the lake is filled. A second potential borrow site would not be inundated. A small volume of material might be taken from this location, which would result in the loss of about 5 acres of upland habitat.

The number and routing of access roads for construction have been carefully considered to minimize adverse environmental impacts. An estimated 33 acres of upland habitat outside the area to be inundated would be altered by the construction of access roads. The reconstruction of existing roads would not result in the alteration of any uplands since they would utilize the existing roadbed. The rerouting of powerline and buried cable rights-of-way would cause the loss of an additional 100 acres of upland habitat.

Spoil piles of the size expected for this alternative have been developed for past construction activities at the Savannah River Plant and have met the necessary environmental control requirements. Spoil from any excavation in the former floodplain of Steel Creek would be monitored for radioactive materials; any spoil containing radioactivity would be disposed of as discussed in Section L.2.4.2.2.

L.2.4.7.2.2 Inundation of habitats

The filling of the cooling lake would inundate 225 acres of wetlands and 775 acres of uplands in the Steel Creek corridor (approximately 150 acres of "jurisdictional wetlands" as defined by the Corps of Engineers). The vegetation in this area consists primarily of scrub-shrub and forested wetlands. These areas are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOl, 1981).

L.2.4.7.3 Water quality

The potential impacts to water quality from construction would be erosion and sedimentation; these potential impacts would be mitigated as described in Section L.2.4.8.3.

L.2.4.7.4 Air quality and noise

About 400 to 550 acres of upland forest would be cleared. Trees of commercial value would be harvested and removed from the site in accordance with the SRP Forest Management Program. Open burning would be employed for disposal of forest slash cleared from the site. Clearing and burning would progress in reasonably sized units of a few acres to minimize local dust and smoke. The nearest roadways to the lake would be SRP Road B (less than 30 meters) and

Highway 125 (1 kilometer). Traffic could be rerouted from Road B if necessary during the burning of slash material. Because of its distance from the construction site, Highway 125 would not be affected. Burning would result in some releases of particulates and gases into the atmosphere, but releases would be local and generally short-lived. Offsite effects are not expected since the nearest location to the SRP site boundary from the lake would be approximately 8 kilometers.

Not all the lake would be grubbed and burned. About 200 acres of lake bottom near the shoreline would be maintained with the stumps in place as habitat for aquatic organisms. Other burnable slash might also be used to construct submerged habitat attraction structures, thus reducing the need to burn all material at the site. Temporary construction roads, laydown areas, and spoil areas would be graded, grassed, wetted, or sprayed with tackifiers as needed to reduce local dust. As much as possible, the roads would be designed to become permanent access roads once the project was completed, thus reducing the impacts of temporary haul roads.

The cooling lake construction site is in a forest area that is relatively remote from human habitation. Noise from construction, primarily from tree-cutting and earth-moving equipment, would have insignificant offsite environmental effect because of the remoteness of the site and the muffling effect of intervening forests. Members of the public using SC Highway 125 would not be in the immediate vicinity of noisy equipment and would have only brief exposure. Effects of this exposure would be insignificant. Noise levels from lake site construction in nearby L-Area, the nearest occupied onsite facility, are expected to be well within clearly acceptable standards (62 decibels). Operators of noisy construction equipment would wear protective equipment in accordance with Du Pont standards (where applicable) and OSHA regulations. Most other workers in the area would be exposed to high noise levels only intermittently, but protective equipment would be provided when the exposure could be expected to be sustained. No impulsive or impact noises in excess of acceptable standards would be expected.

L.2.4.7.5 Socioeconomic

The construction of the 1000-acre lake would be completed over a 6-month period at a capital cost of approximately \$25 million and an annual operation cost of \$3.4 million. The present worth of this alternative would be \$111 million and the annualized cost would be \$13.1 million. The construction would require about 550 workers. The potential economic effects on the local economy are expected to be positive; however, these effects will be small (in relation to other ongoing SRP projects--DWPF and FMF) and of short duration (6 months). Impacts to local community facilities and services are expected to be minor because most construction personnel will be hired from within the Central Savannah River Area. Such personnel are presently available because the Richard B. Russell Dam construction is near completion.

L.2.4.7.6 Land use

The 1000-acre cooling lake would be entirely within the present SRP area boundaries. Land use within the SRP area would be altered, in that 1000 acres would be inundated to become a cooling lake and the previous land uses as forest land and bottom land would be interrupted. The 1000 acres would include

450-600 acres of wetland in the Steel Creek Corridor and 400-550 acres of up-land. Timber of commercial value would be harvested and removed from the site in accordance with SRP Forest Management Program. An additional area (about 100 acres) would be cleared for road and utility access relocation.

The timber which would be harvested consists of pine saw timber, pine pulp wood, hardwood saw timber, and hardwood pulp wood. Table L-1 summarizes the timber value and annual growth. The anticipated value from harvesting the timber is \$950,000. The annual loss in timber productivity is projected to be \$44,000. This impact is not amenable to mitigation.

Table L-1. Timber value and annual growth

Type of timber	Present Volume/Value			Annual Growth	
	Volume (1000 board feet)	Cords	Value (\$1000)	Volume (%)	Value (\$1000)
Pine, saw timber	5058	--	715	4	28
Pine, pulp wood	--	4326	102	8	12
Hardwood, saw timber	2550	--	128	3	4
Hardwood, pulp wood	--	3384	5	6	.3
Totals	--	--	950	--	44

L.2.4.8 Construction impact mitigation

L.2.4.8.1 Historic/archeological site mitigation

A monitoring and mitigation plan has been developed to ensure the preservation of the resources at the four sites below the dam, and the plan has been approved by the South Carolina State Historic Preservation Officer (SHPO) (Du Pont, 1983a).

A resource recovery plan has been developed by the University of South Carolina Institute of Archaeology and Anthropology for the one historic site (38 BR 288) located within the proposed lake area. This mitigation plan has been approved by the SHPO and the Advisory Council on Historic Preservation (ACHP) (Lee, 1982), which concurred that this mitigation plan will result in no adverse impacts to National Register properties.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina, Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation

will be completed prior to restart (Hanson, 1984). The study results, determination of eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

L.2.4.8.2 Ecological mitigation

The Department of Energy is working with the Department of the Interior to perform a Habitat Evaluation Procedure (HEP). The HEP will identify the value of habitat to be gained or lost with implementation of the preferred cooling-water mitigation alternative for use in assessing further mitigation. If required, DOE will implement additional mitigative measures that might be identified through the HEP process, dependent on Congressional authorization and appropriation.

The endangered wood stork forages at the Savannah River Plant but does not breed on the site. The feeding individuals have been observed to be from the Birdsville Rookery, some 50 kilometers away. Feeding occurs in the swamp away from the proposed lake; it could be affected by raised water levels in the Steel Creek delta if the L-Reactor cooling-water flow is discharged through the proposed lake. DOE initiated informal consultation with the Fish and Wildlife Service (FWS) in July 1983 and in March 1984 as required by Section 7 of the Endangered Species Act. DOE has also initiated the formal consultation process by providing a Biological Assessment to FWS for a Biological Opinion (Sires, 1984a). While DOE concludes that the operation of L-Reactor will affect foraging habitat near the Steel Creek delta, the construction activities associated with Phase II of the NPDES permit to control the acidity of releases from the 400-area powerhouse ash basins will improve the quality of the foraging habitat in the Beaver Dam Creek area, assuring the continued availability of this habitat. Therefore, the loss of foraging habitat in the Steel Creek area will not jeopardize the continued existence of the wood stork. Any additional mitigation measures needed will be determined either as part of the HEP study or as part of this consultation process.

L.2.4.8.3 Water quality mitigation

The lake construction activity would include an Environmental Protection Plan, which would include several measures designed to mitigate water quality impacts.

Earthwork brought to final grade would be protected as soon as practicable. All earthwork would be planned and conducted to minimize the duration of exposure of unprotected soils. Except in instances where the constructed feature obscures borrow areas and waste material areas, these areas would not initially be cleared in total. Clearing of such areas would progress in reasonably sized increments as needed.

Such methods as necessary would be utilized to effectively prevent erosion and control sedimentation, including but not limited to the following:

1. Retardation and control of runoff. Runoff from the construction site would be controlled by construction of diversion ditches, benches, and berms to retard and divert runoff to protected drainage courses.

2. Sediment basins. Sediment from construction areas would be trapped in temporary or permanent sediment basins in accordance with design plans. The basins would accommodate the runoff of anticipated storms. After each storm the basins would be pumped dry and accumulated sediment would be removed as necessary to maintain basin effectiveness. Overflow would be controlled by paved weir or by vertical overflow pipe, draining from the surface. The collected topsoil sediment would be reused for fill on the construction site, and/or conserved (stock-piled) for use elsewhere. Effluent quality monitoring programs would be required.

Temporary erosion and sediment control measures such as berms, dikes, drains, sedimentation basins, grassing and mulching would be maintained until permanent drainage and erosion control facilities were complete and operative.

Borrow areas and spoil-storage areas would be managed to minimize erosion and to prevent sediment from entering nearby water courses or lakes. Temporary excavations and embankments for work areas would be controlled to protect adjacent areas from despoilment.

Solid wastes (excluding clearing debris) would be placed in containers which would be emptied on a regular schedule. All handling and disposal would be conducted to prevent contamination. Chemical waste would be stored in corrosion-resistant containers, removed from the work area, and disposed of in accordance with Federal, state and local regulations.

Construction activities would be kept under surveillance, management and control to avoid pollution of surface and ground waters. The following special management techniques would be implemented to control water pollution: (1) wastewaters from construction activities would not be allowed to leave the site; they would be collected in retention ponds where suspended material could be settled out or the water could be evaporated so the pollutants would be separated; (2) the operation would be planned to minimize adverse impacts of dewatering, removal of cofferdams, and excavation, and to limit the impact of water turbidity on the habitat for wildlife and impacts on water quality for downstream use; (3) stream crossings would be controlled during construction; crossings would allow the movement of materials or equipment that did not violate Federal or state water pollution control standards; (4) all water areas affected by construction activities would be monitored; (5) construction activities would be kept under surveillance, management, and control to minimize interference with, disturbance to, and damage of fish and wildlife.

L.2.4.8.4 Air emissions and noise control

The construction Environmental Protection Plan would also require measures to mitigate air emissions and noise. Construction activities would be kept under surveillance, management, and control to minimize pollution of air resources. All activities, equipment, processes, and work performed would be in strict accordance with applicable requirements.

The following special management techniques would be implemented to control air pollution by the construction activities:

1. Dust particles, aerosols, and gaseous byproducts from all construction activities, processing and preparation of materials would be controlled at all times, including weekends, holidays, and hours when work is not in progress.
2. Particulates that could cause the air pollution standards to be exceeded or that could cause a hazard or a nuisance would be controlled at all excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and all other work areas inside or outside the project boundaries. Sprinkling, chemical treatment of an approved type, light bituminous treatment, or other methods would be utilized to control particulates in the work area. Sprinkling would be repeated at intervals to keep the disturbed area damp. Particulate control would be performed as the work proceeded and whenever a particulate nuisance or hazard occurred.
3. Hydrocarbons and carbon monoxide emissions from equipment would be controlled to Federal and State allowable limits at all times.
4. Odors would be controlled at all times for all construction activities, processing and preparation of materials.
5. Air at all areas affected by the construction activities would be monitored.

Construction activities would be kept under surveillance and control to minimize damage to the environment by noise. Methods and devices would be used to control noise emitted by equipment to the levels shown in the COE, Savannah District Safety Manual (COE, 1981a).

L.3 COOLING-LAKE AFFECTED ENVIRONMENT

L.3.1 Geography

L.3.1.1 Location

The Savannah River Plant (SRP), including the L-Reactor and the proposed cooling lake, is located in southwestern South Carolina. The Plant occupies an almost circular area of approximately 780 square kilometers, bounded on its southwestern side by the Savannah River, which is also the Georgia-South Carolina border. Chapter 3, Section 3.1 presents the site location in relation to major population centers, the closest being Augusta, Georgia, and Aiken and Barnwell, South Carolina.

L.3.1.2 Historic/archeologic sites

During January and February 1981, a survey was conducted of the Steel Creek terrace and floodplain system below L-Reactor for archeological resources and sites that might qualify for inclusion in the National Register of Historic Places (Hanson et al., 1981). The area of Steel Creek surveyed was 13 kilometers long and 300 meters wide. Archeologists traversed the first and second terraces of the creek system, inspecting 4-square-meter plots every 5 meters along the creek.

The survey identified 18 historic and archeological sites along Steel Creek below L-Reactor. One archeological site, located at the confluence of Steel Creek and Meyers Branch, was considered significant in terms of National Register criteria. In July 1982, the DOE requested the concurrence of the Keeper of the National Register on this site's eligibility for nomination to the National Register. The Keeper concurred in this site's eligibility.

Seven additional sites were considered potentially significant in terms of National Register criteria. Three of these sites occur beyond the area of any potential effects from the 1000-acre lake alternative. The remaining four sites include three mill dams that date to the early nineteenth century and an historic roadway across the Steel Creek floodplain. In July 1982, the DOE requested the concurrence of the Keeper of the National Register regarding the eligibility of these sites for nomination to the National Register. The Keeper of the National Register concurred in the eligibility of these four sites for inclusion in the National Register. These sites are potentially affected. The remaining 10 sites were not considered significant.

In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described to be of ephemeral quality and not eligible for nomination to the National Register of Historic Places. DOE has provided this report to the SHPO to receive his concurrence in the conclusion that no eligible sites are located in the impact area.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984). The study results, the determination of the eligibility of potential sites, and the development of a mitigation plan are being coordinated with the SHPO and ACHP.

L.3.2 Socioeconomic and community characteristics

Section 3.2 of this EIS provides a summary discussion of all aspects of socioeconomics and community characteristics in the SRP areas. Additional information on these topics can be found in the Socioeconomic Baseline

Characterization for the Savannah River Plant Area, 1981 (ORNL, 1981) and the Final Environmental Impact Statement, Defense Waste Processing Facility, Savannah River Plant, Aiken, South Carolina (DOE, 1982a). The impacts of the 1000-acre lake would be related primarily to jobs in connection with the construction.

L.3.3 Geology and seismology

L.3.3.1 Geology

L.3.3.1.1 Geologic setting

The L-Reactor cooling lake would be located in the Aiken Plateau physiographic division of the Upper Atlantic Coastal Plain of South Carolina (Cooke, 1936; Du Pont, 1980a). Figure 3-5 shows that the topography in the vicinity of the L-Reactor site at the Savannah River Plant is characterized by interfluvial areas with narrow, steep-sided valleys. The relief in the region of the cooling-lake embankment site measures about 56 meters.

The proposed site for the cooling-lake embankment is about 40 kilometers southeast of the Fall Line (Davis, 1902) that separates the Atlantic Coastal Plain physiographic province from the Piedmont physiographic province of the Appalachian region (Appendix F, Figure F-1). Crystalline rocks of Precambrian and Paleozoic age underlie the gently seaward-dipping Coastal Plain sediments of the Cretaceous and younger ages. Sediment-filled basins of Triassic and Jurassic age (exact age is uncertain) occur within the crystalline basement throughout the coastal plain of Georgia and the Carolinas (Du Pont, 1980a). One of these, the Dunbarton Triassic Basin, underlies parts of Savannah River Plant.

L.3.3.1.2 Stratigraphy

Coastal Plain sediments in South Carolina range in age from Cretaceous to Quaternary; they form a seaward-dipping and thickening wedge of interstratified beds of mostly unconsolidated sediments. At the cooling-lake site, these sediments are approximately 400 meters thick (Siple, 1967). The base of the sedimentary wedge rests on a Precambrian and Paleozoic crystalline basement, which is similar to the metamorphic and igneous rocks of the Piedmont, and on the siltstone and claystone conglomerates of the down-faulted Dunbarton Triassic Basin. Immediately overlying the basement is the Tuscaloosa Formation of the Upper Cretaceous age, which is about 230 meters thick and composed of prolific water-bearing sands and gravels separated by prominent clay units. Overlying the Tuscaloosa is the Ellenton Formation, which is about 18 meters thick and consists of sands and clays interbedded with coarse sands and gravel. Four of the formations shown in Figure 3-5--the Congaree, McBean, Barnwell, and Hawthorn--comprise the Tertiary (Eocene and Miocene) sedimentary section, which is about 85 meters thick and consists predominantly of clays, sands, clayey sands, and sandy marls. The near-surface sands of the Barnwell and Hawthorn Formations are usually in a loose to medium-dense state; they often contain thin sediment-filled fissures (clastic dikes) (Du Pont, 1980a).

Quaternary alluvium has been mapped at the surface in floodplain areas. Soil horizons at the site are generally uniform and relatively shallow, about

1 meter deep. They are characterized by bleached Barnwell-Hawthorn sediments, which result in a light tan sandy loam. Section 3.4.2 and Appendix F present additional stratigraphic information.

L.3.3.2 Seismology

L.3.3.2.1 Geologic structures

The Dunbarton Triassic Basin, which is similar to grabens in the Basin and Range Province in Nevada, underlies the Savannah River Plant at the L-Reactor site (Siple, 1967). Other Triassic-Jurassic basins have been identified in the Coastal Plain tectonic province within 300 kilometers of the site (Du Pont, 1980a; Popenoe and Zietz, 1977). The Piedmont, Blue Ridge, and Valley and Ridge tectonic provinces, which are associated with Appalachian mountain building, are northwest of the Fall Line. Several fault systems occur in and adjacent to the Piedmont and the Valley and Ridge tectonic provinces of the Appalachian system; the closest of these is the Belair Fault Zone, about 40 kilometers from the site. The U.S. Nuclear Regulatory Commission has determined that the Belair Fault is not capable within the meaning of 10 CFR 100 (Case, 1977). Studies sponsored by Georgia Power Company have shown that the faults postulated to occur near the southeastern boundary of the Savannah River Plant and about 40 kilometers farther southeast (Faye and Prowell, 1982) are not capable and that they might not exist (Georgia Power Company, 1982). There is no evidence of any recent displacement along any faults within 300 kilometers of the cooling-lake dam site (Du Pont, 1980a). In addition, no apparent association exists between local seismicity and specific faults near the Savannah River Plant, with the possible exception of the geophysically inferred faults (Lyttle et al., 1979; Behrendt et al., 1981; Talwani, 1982) in the meizoseismal area of the 1886 Charleston earthquake, which occurred approximately 145 kilometers from the Plant (Du Pont, 1982a).

Surface mapping and subsurface investigations in the L-Reactor region did not detect any faulting of the sedimentary strata or any other geologic hazards that would pose a threat to the reactor. Several surficial faults, generally less than 300 meters in length and with displacements of less than 1 meter, were mapped within several kilometers of the L-Reactor site. None of these faults is considered capable (Du Pont, 1980a).

L.3.3.2.2 Seismicity

Two major earthquakes have occurred within 300 kilometers of the proposed cooling-lake site: the Charleston earthquake of 1886, which had an epicentral Modified Mercalli Intensity (MMI) of X, was located about 145 kilometers away; and the Union County, South Carolina, earthquake of 1913, which had an epicentral shaking of MMI VII to VIII, was located approximately 160 kilometers away (Langley and Marter, 1973). An estimated peak horizontal shaking of 7 percent of gravity (0.07g) was calculated for the site during the 1886 Charleston earthquake (DOE, 1982b). No reservoir-induced seismicity is associated with Par Pond (Du Pont, 1982a).

Probabilistic and deterministic analyses commensurate with the criteria used by NRC (10 CFR 100) have established a design-basis earthquake acceleration of 0.20g for key seismic-resistant buildings at the Savannah River Plant. This acceleration is predicted to be exceeded only once in about 5000 years (Du Pont, 1982a). An evaluation of seismic forces would be included in the outlet works tower stability analysis; the joints would be designed to withstand seismic-induced movement.

L.3.4 Hydrology

L.3.4.1 Surface-water hydrology

L.3.4.1.1 Savannah River

The Savannah River Plant is drained almost entirely by the Savannah River, one of the major drainage networks in the southeastern United States (Langley and Marter, 1973). The peak historic flood between 1796 and 1983--10,190 cubic meters per second--corresponds to a stage of about 36 meters (DOE, 1982b). A domino-type failure of dams on the Savannah River above the Savannah River Plant would produce a flow of 42,500 cubic meters per second with a corresponding stage of 43.6 meters at the Plant (Du Pont, 1980a). Both of these flood stages are above the base of the proposed cooling-lake embankment (elevation 35 meters); however, only backwaters would reach the downstream embankment face, because a ridge on the west side of Steel Creek would shelter the embankment. The two nearest upstream reservoirs, Clarks Hill (completed in March 1953, with 3.1×10^9 cubic meters of storage) and Hartwell (completed in June 1961, with 3.1×10^9 cubic meters of storage), provide power, flood control, and recreational areas. These reservoirs and the New Savannah River Bluff Lock and Dam at Augusta, Georgia, have stabilized the river flow at Augusta to a yearly average of 288.8 cubic meters per second (Bloxham, 1979) and 295 cubic meters per second at Savannah River Plant. Russell Reservoir, which began filling in December 1983, will furnish 1.2×10^9 cubic meters of storage to further stabilize Savannah River flows.

Since 1963, it has been the operating practice of the U.S. Army Corps of Engineers to attempt to maintain a minimum flow of 178.4 cubic meters per second below the New Savannah River Bluff Lock and Dam at Butler Creek (River Mile 187.4, near Augusta, Georgia) (COE, 1981b). During the 18-year period from 1964 to 1981 (climatic years ending March 31), the average of the lowest 7-consecutive-day flow each year measured at the New Savannah River Bluff Lock and Dam was 181 cubic meters per second (Watts, 1982), or about 2.3 cubic meters per second less than at Savannah River Plant (Ellenton Landing, River Mile 156.8). The 7-day, 10-year low flow of the river at SRP is calculated to be 159.0 cubic meters per second.

Figure 3-6 shows the mean monthly flow rates for the Savannah River measured at Augusta, Georgia, from January 1964 through September 1981. The highest flows occur in the winter and spring, and the lowest occur in the summer and fall. This figure also indicates long-term mean and 7-day, 10-year low flows at Ellenton Landing.

Duke Power Company has entered into an agreement with the City of Greenville, South Carolina, to provide an interbasin transfer of as much as 0.53 cubic meter per second in 1985 and 8.3 cubic meters per second by 2020 from Lake Keowee. The States of Georgia and South Carolina have asked the Corps of Engineers for permission to withdraw as much as 1.8 cubic meters per second (total) from Lake Hartwell. The Corps of Engineers maintains, in accordance with its agreement with Duke Power Company, that the interbasin transfer from Lake Keowee to the City of Greenville is legal provided it has no effect on the ability of the Corps to generate electric power at Lake Hartwell and Clarks Hill. The Corps of Engineers is presently assessing the requests by South Carolina and Georgia to withdraw water from Lake Hartwell. This assessment will include the ability of the Corps to maintain its navigation project below the New Savannah Bluff Lock and Dam and to meet its electric-power-generation requirements. It will also consider the effects of the interbasin transfer. Until the Corps of Engineers completes its assessment, it will maintain the flow below the New Savannah Bluff Lock and Dam at the current levels.

The 1979-1982 average temperature of the Savannah River 3 kilometers above the Savannah River Plant was 17.8°C, with a range of 1.5° to 25.0°C. Similarly, below the Plant, the average temperature was 18.4°C and the range was 6.5° to 26.0°C. Figure 3-7 shows monthly average daily-maximum temperatures above and below the Savannah River Plant for the period 1960-1970. As shown in that figure, June, July, August, and September are the warmest river temperature months. The average river temperature during these months is about 25 percent higher than the annual average river temperature. From June 1955 through September 1982, the river temperature at Ellenton Landing equaled or exceeded 28°C three times and equaled or exceeded 28.3°C once. During the February, March, April, and May fish-spawning season, the monthly average daily-maximum temperatures (and standard deviations) at Ellenton Landing were 8.7°C (1.0°C), 11.0°C (1.3°C), 15.4°C (1.3°C), and 18.8°C (1.6°C), respectively.

L.3.4.1.2 SRP streams and swamp

The SRP site is drained almost entirely by five principal systems (drainage areas are in parentheses): (1) Upper Three Runs Creek (490 square kilometers); (2) Four Mile Creek, including Beaver Dam Creek (90 square kilometers); (3) Pen Branch (90 square kilometers); (4) Steel Creek (90 square kilometers); and (5) Lower Three Runs Creek (470 square kilometers). These streams rise on the Aiken Plateau and descend 30 to 60 meters before discharging to the Savannah River. The sandy soils of the area permit rapid infiltration of rainfall; seepage from these soils furnishes the streams with a rather constant supply of water through most of the year (Langley and Marter, 1973).

The three streams that have received the greatest input of thermal effluent (Four Mile Creek, Pen Branch, and Steel Creek) flow into a contiguous swamp of about 10,240 acres (Du Pont, 1983b) that is separated from the main flow of the Savannah River by a 3-meter-high natural levee along the river bank. These streams generally flow as shallow sheets, with well-defined channels only where they enter the swamp and near breaches in the levee (Smith, Sharitz, and Gladden, 1981). The combined natural flow and reactor effluent discharges have a strong influence on water levels in the swamp during nonflood conditions.

The flow of water in the swamp is altered when the Savannah River is in flood stage (about 27.7 meters) with a flow rate of about 440 cubic meters per

second. Under flooding conditions, Four Mile Creek, Pen Branch, and Steel Creek discharge to the Savannah River at Little Hell Landing after crossing an offsite swamp (Creek Plantation Swamp). An analysis of the data from 1958 through 1980 indicates that on the average the Savannah River reaches flood stage at the Savannah River Plant 79 days or 22 percent of each year, predominantly from January through April. This result is in agreement with the results of a similar analysis performed by Langley and Marter (1973).

The L-Reactor site is drained by both Steel Creek and Pen Branch. Steel Creek was used from 1955 to 1968 to receive the reactor coolant discharge. The headwaters of Steel Creek rise near P-Area and flow southwesterly for about 7 kilometers, turn south for about 9 kilometers, and enter the Savannah River swamp about 3 to 5 kilometers from the river. A delta of about 100 acres surrounded by a partial tree-kill zone of another 180 acres has developed where the creek enters the swamp (Du Pont, 1983a). Beyond the delta, Steel Creek is joined by the flow from Pen Branch and some flow from Four Mile Creek before it discharges into the Savannah River near Steel Creek Landing (see Figure 3-2).

During the 1983 water year (October 1982 through September 1983), the flow of Steel Creek at Road B ranged between 0.28 and 3.96 cubic meters per second. The average flow for this period was 0.62 cubic meter per second. During the 4-month period from October 1983 to January 1984, the flow at Road B ranged from 0.19 to 4.39 cubic meters per second, and the average flow was 1.00 cubic meter per second. Of the average flow, about 0.45 cubic meter per second was discharged from P-Reactor at near-ambient temperatures (McAllister, 1983). Farther downstream at Cypress Bridge, about 2.8 kilometers below Road A, the average flow of Steel Creek during calendar years 1978 through 1980 was 1.36 cubic meters per second. During the 1983 water year, this flow ranged from 0.65 to 5.95 cubic meters per second and the average flow was 1.91 cubic meters per second. During the 4-month period from October 1983 to January 1984, this flow ranged from 1.13 to 5.55 cubic meters per second, with an average of 2.74 cubic meters per second. After subtracting the P-Reactor contribution, the natural flow of Steel Creek at Cypress Bridge is calculated to be about 0.91 cubic meter per second. Du Pont (1982b) estimated the natural flow of Steel Creek to be 1.0 cubic meter per second, based on drainage area considerations. Maximum daily flow rates (both natural storm runoff and with discharges from P-Reactor) were measured between 4.2 and 8.2 cubic meters per second during the past 8 years.

Steel Creek has had a varied history with respect to the release of reactor effluents. The release of thermal effluents into Steel Creek from L- and P-Reactors reached a peak of about 23 cubic meters per second in 1961. In 1963, P-Reactor effluents were diverted to Par Pond, and thermal discharges to the creek were reduced to about 11 cubic meters per second, about 1.3 times the maximum natural flow expected at Cypress Bridge after heavy rains. Since 1968, Steel Creek has received only infrequent and short-term inputs of thermal effluents (Smith, Sharitz, and Gladden, 1981, 1982a; Du Pont, 1982b). Between 1951 and 1972, the Steel Creek channel width increased more than three times due to effluent scour.

At the present time, several effluents from P-Reactor area normally flow into either Steel Creek or Meyers Branch. The effluents to Steel Creek consist of the process sewer outfall (0.45 cubic meter per second); infrequent cooling water from P-Reactor, and storm water outfall. The normal effluents to Meyers Branch include (1) overflow from ash settling/seepage basin (0.01 cubic meter

per second), (2) periodic overflow from the coal pile runoff basin, (3) non-process cooling water (0.02 cubic meter per second), and (4) storm water outfalls.

Figure L-16 shows recent water temperatures along Steel Creek at Cypress Bridge, about 2.8 kilometers below Road A. The figure shows the temperature ranges and averages of monthly grab samples taken during the period of July 1973 through December 1982.

Water samples were taken every 2 weeks from 7 locations along Steel Creek and Meyers Branch between November 2, 1983, and January 31, 1984 (seven samples from each location) and analyzed for several constituents. Figure L-17 shows the sampling locations; Table L-2 lists the chemical analyses.

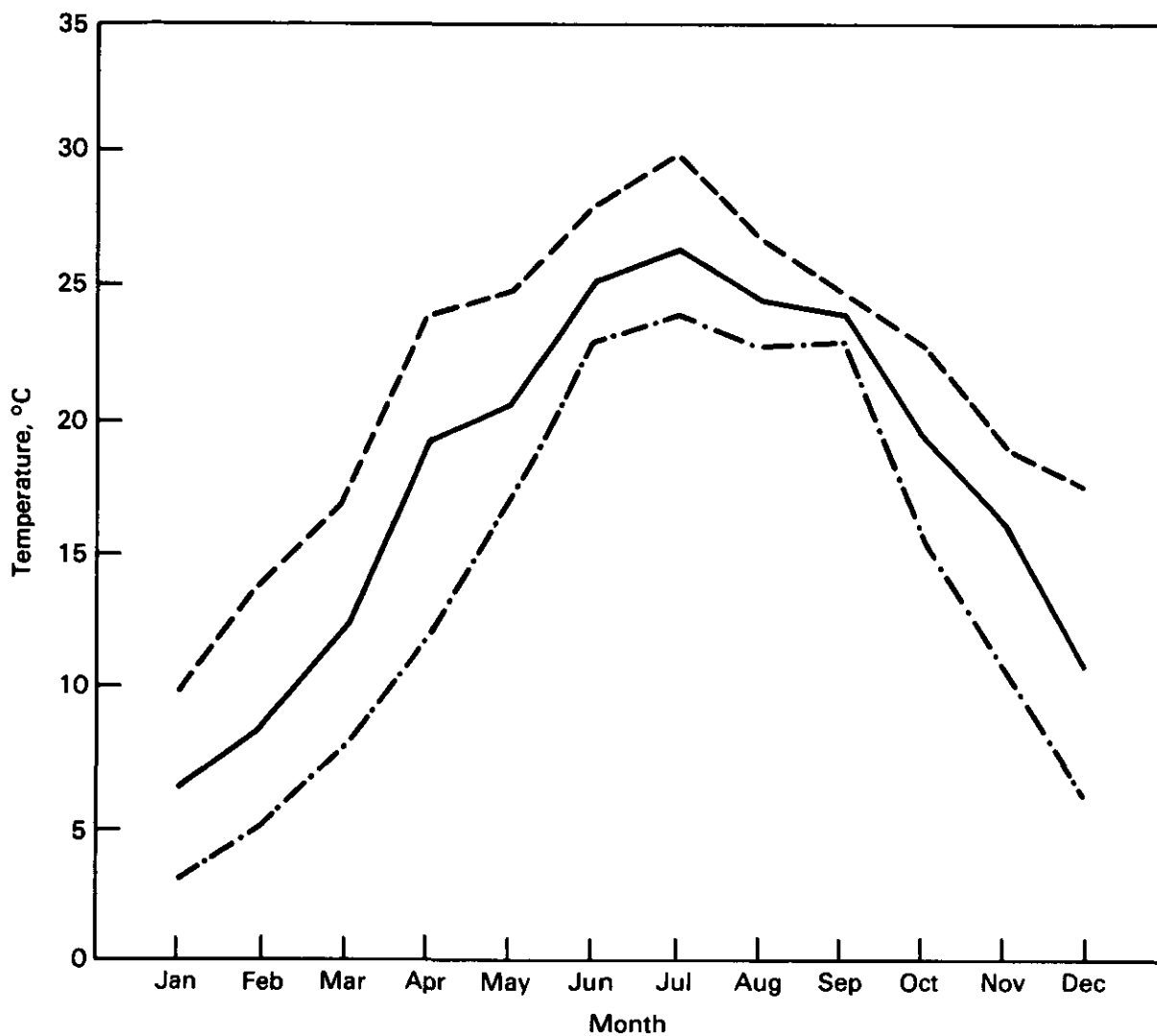
L.3.4.1.3 Design floods on Steel Creek

The design floods for the 1000-acre lake were modeled by computer analysis, using the latest revision of the U.S. Army Corps of Engineers' HEC-1 program. In the applications to this project, the program computed the lake inflow hydrograph (flow rate vs. time), then "routed" this hydrograph through the lake to produce the lake outflow hydrograph and lake surface elevations throughout the storm. The input required to produce the inflow hydrograph included the rainfall hydrograph (rainfall amounts vs. time), drainage area, percent of the area which is impervious, and parameters which reflect the response time of the watershed and the infiltration capability of the pervious fraction of the watershed. The input required to route the inflow hydrograph through the lake included the initial lake elevation and the "stage-storage-discharge" characteristics of the lake (i.e., volume of storage and outflow rate for various lake elevations).

The standard project flood assumes a 4-day storm of 51 centimeters. The rainfall intensity varies throughout the event. The most intense 30-minute period produced 8 centimeters of rainfall. The characteristics of this storm are discussed in detail in Section L.2.3.1. This storm produced 37 centimeters of runoff (rainfall minus infiltration) and a peak inflow rate of 403 cubic meters per second. As this flood wave entered the lake the lake level rose while outflow was released through the principal outlet works at a much lower rate. The peak outflow rate was 29 cubic meters per second and the peak lake elevation was 59.4 meters, about 1.6 meters below the top of the embankment. As a result of the existence of the lake, flood damage to lower Steel Creek would be substantially reduced.

The probable maximum flood (PMF) is a measure of the results of the most intense storm that is meteorologically possible for an area. Its probability of occurrence is so low that no attempt was made to relate it to a recurrence interval. Despite its extremely low probability of occurrence, it was incorporated into the design bases in order to test the adequacy of the natural saddle which is to serve temporarily as the emergency spillway.

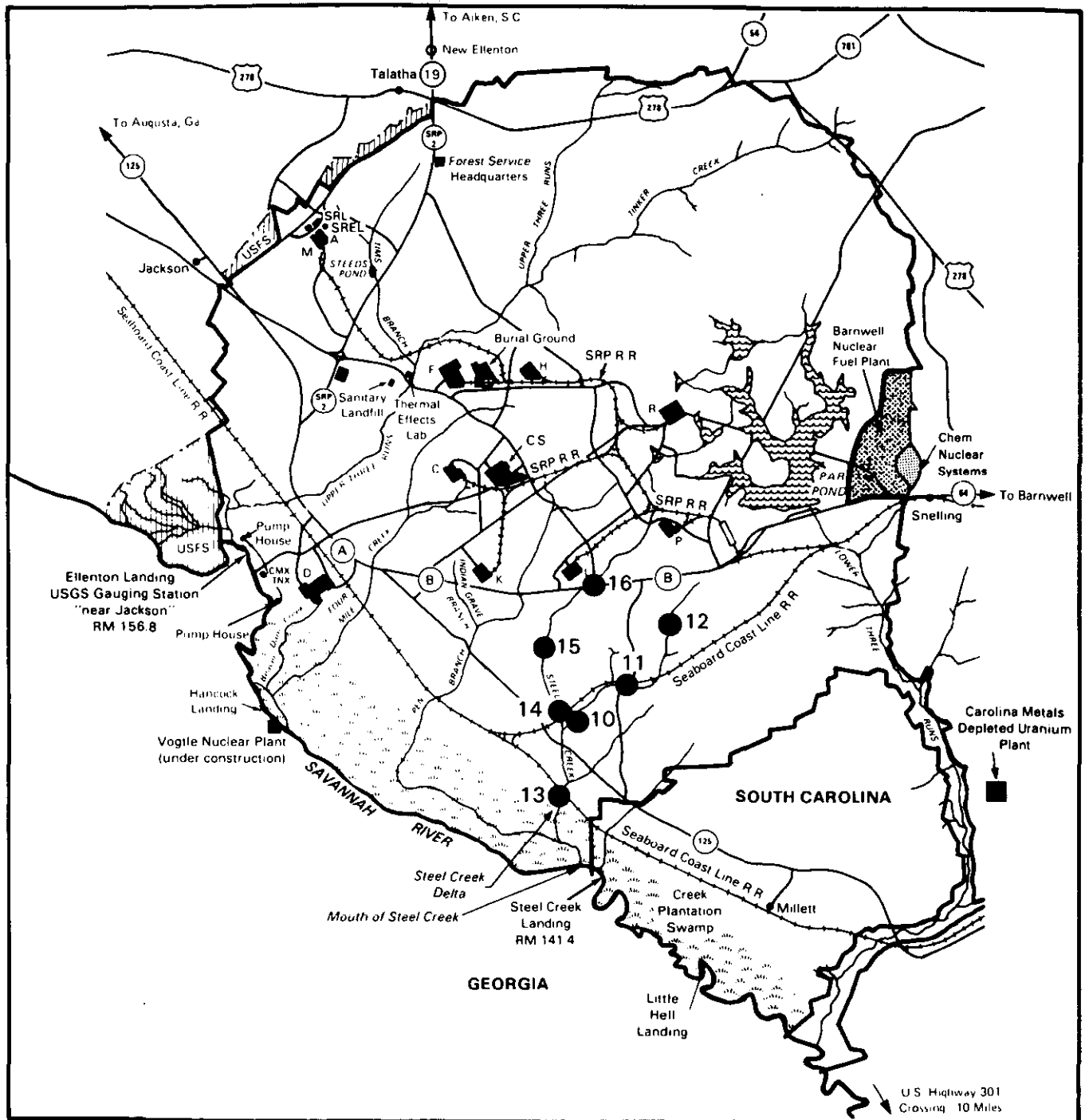
The storm which produced the PMF totaled 72 centimeters in 24 hours, with a peak 30-minute rainfall of 16.3 centimeters. The storm produced 57 centimeters of runoff, with a peak flowrate of 848 cubic meters per second. The peak lake outflow rate was 42 cubic meters per second while the lake elevation rose to



Legend:

- Maximum temperature
- Mean temperature
- .- Minimum temperature

Figure L-16. Temperatures of monthly grab samples taken from Steel Creek from July 1973 through December 1982.



Legend:

● Water quality station

0 5 10 15 kilometers



Figure L-17. Water sampling sites, Steel Creek and Meyers Branch.

Table L-2. Chemical composition of water samples taken from Steel Creek and Meyers Branch, November 1983 to January 1984

Constituent	Units	Average concentration at sample site						
		10	11	12	13	14	15	16
Water temperature	°C	9.9	9.6	9.5	11.1	12.0	12.7	12.7
pH	-	7.4	7.2	7.1	7.6	7.2	7.3	7.3
Specific conductance	µmhos/cm	33	33	48	56	42	54	52
Dissolved oxygen	mg/liter	8.3	8.4	7.6	8.0	8.1	8.2	8.2
Alkalinity (CaCO ₃)	mg/liter	15.2	12.3	11.7	16.6	16.1	15.1	14.8
Chlorides	mg/liter	3.2	3.8	5.7	5.4	5.9	6.1	6.7
Total dissolved solids	mg/liter	1.9	3.6	2.3	8.1	18.7	16.7	15.4
Turbidity	NTU units	2.8	3.5	1.9	11.6	25.1	21.1	33.1
Total phosphorous (P)	mg/liter	0.012	0.020	0.043	0.050	0.053	0.054	0.038
Total orthophosphate (P)	mg/liter	0.016	0.010	<0.01	0.017	0.029	0.036	0.027
Dissolved orthophosphate (P)	mg/liter	<0.01	<0.01	<0.01	0.01	0.02	0.03	0.03
Nitrates (N)	mg/liter	0.07	0.08	0.09	0.18	0.26	0.27	0.28
Nitrites (N)	mg/liter	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Ammonia (N)	mg/liter	0.01	0.01	0.03	0.02	0.02	0.03	0.02
Total Kjeldahl nitrogen (N)	mg/liter	0.12	0.12	0.11	0.15	0.14	1.22	0.09

60.5 meters, 0.3 meters above the lowest point on the saddle but 0.5 meter below the top of the embankment.

About 12 cubic meters per second of the peak outflow would pass over the saddle to Pen Branch. The maximum average velocity of flow over the saddle would be 6 centimeters per second. This is a mild velocity for a grassed waterway, so little, if any, damage would occur. As in the case of the standard project flood, substantial flood-damage reduction downstream of the embankment would result from the lake's ability to attenuate the peak flow from 848 cubic meters per second to 42 cubic meters per second.

L.3.4.1.4 Surface-water use

Downstream from Augusta, Georgia, the Savannah River is classified by the State of South Carolina as a Class B waterway, suitable for agricultural and industrial use, the propagation of fish, and--after treatment--domestic use. The river upstream from the Savannah River Plant supplies municipal water for Augusta, Georgia, and North Augusta, South Carolina. Downstream, the Beaufort-Jasper Water Authority in South Carolina (River Mile 39.2) withdraws about 19,700 cubic meters per day (0.23 cubic meter per second) to supply domestic water for a population of about 51,000. The Cherokee Hill Water Treatment Plant at Port Wentworth, Georgia (River Mile 29.0), withdraws about 116,600 cubic meters per day (1.35 cubic meters per second) to supply a business-industrial complex near Savannah, Georgia, that has an estimated consumer population of about 20,000 (Du Pont, 1982b). Plant expansions for both systems are planned for the future.

The Savannah River Plant currently withdraws a maximum of 26 cubic meters per second (about 63 percent of the maximum pumping rate of 41 cubic meters per second) from the river, primarily for use as cooling water in production reactors and coal-fired power plants (Du Pont, 1982b). Almost all of this water returns to the river via SRP streams (Du Pont, 1981a). The river receives sewage treatment effluents from Augusta, Georgia, and North Augusta, Aiken, and Horse Creek Valley, South Carolina, and other waste discharges along with the heated cooling water from the Savannah River Plant via its tributaries. The cooling-water withdrawal and discharge rate of about 1.2 cubic meters per second for both units of the Alvin Vogtle Nuclear Plant is expected later in the 1980s (Georgia Power Company, 1974). The Urquhart Steam Generating Station at Beech Island withdraws approximately 7.4 cubic meters per second of once-through cooling water. Upstream, recreational use of impoundments on the Savannah River, including water contact recreation, is more extensive than it is near the Savannah River Plant and downstream. No uses of the Savannah River for irrigation have been identified in either South Carolina or Georgia (Du Pont, 1982b).

The water quality of the Savannah River is discussed in Chapter 4. Historic data demonstrate that the water quality of the river downstream of the Savannah River Plant is similar to the water quality upstream (Marter, 1970).

L.3.4.2 Subsurface hydrology

The Coastal Plain sediments, which contain several prolific and important aquifers, consist of a wedge of stratified sediments that thickens to the south-east. Near L-Reactor, the sediments are about 400 meters thick and consist of sandy clays and clayey sands. The sandier beds form aquifers and the clayier beds form confining beds. The Coastal Plain sediments across the SRP generally consist of the Barnwell (combined with the Hawthorn as one mapping unit), McBean, Congaree, Ellenton, and Tuscaloosa Formations (Figure 3-5). Among these, the Tuscaloosa Formation is a particularly prolific ground-water unit because of both its thickness and its high permeability. Surficial deposits, including terrace sediments and alluvium, are not important sources of ground water at SRP. The lithology and water-bearing characteristics of the hydro-stratigraphic units underlying the Savannah River Plant are described in Table 3-8. Additional detail is provided in Table F-1 and the text of Appendix F.

In the central part of the Savannah River Plant (including F-, H-, and L-Areas), the Barnwell and McBean Formations, and the McBean and Congaree Formations are separated by layers informally called the "tan clay" and the "green clay," respectively. The lowest unit of the Barnwell Formation is the tan clay. Borings in the Separations Areas and about 2 kilometers east of the Central Shops (Figure 3-2) indicate that the tan clay is about 2 meters thick, and that it commonly consists of two thin clay layers separated by a sandy zone (Du Pont, 1983c, D'Appolonia, 1980). In the L-Area, the tan clay is not readily evident from foundation borings, drillers logs, or geophysical logs; however, even in other areas of the SRP where it supports a significant head difference, this clay is not always apparent in soil cores alone.

In the L-Area the green clay, based on geophysical logs of water wells 104L and 55-2, is about 7 meters thick. At the Par Pond pumphouse, along the strike from L-Reactor, the green clay also apparently supports a large head difference; it also appears to have protected the Congaree ground water effectively from the large (27,000 picocuries per liter) concentrations of tritium in Par Pond (Ashley and Zeigler, 1981). In the central part of the SRP, this clay directs much of the water in the McBean laterally to local creeks.

Throughout the SRP, the clay at the base of the Congaree and the upper clay layer of the Ellenton Formation provide an effective confining unit for the sands of the Ellenton-upper Tuscaloosa Aquifer (see Table F-1).

As shown on Figure 3-8, the heads in the Ellenton and Tuscaloosa Formations are higher than those in the Congaree (upward head differentials) in the central portion of the SRP, thus preventing the downward movement of water from the Congaree to the Ellenton where this condition exists. This condition is caused by the drawing down of the head in the Congaree by natural drainage into Upper Three Runs Creek and the Savannah River. Figure 3-4 shows an approximation of the area where the head difference is upward from the Tuscaloosa to the Congaree; F-, H-, and L-Areas are within this area, but M-Area is not.

Figure 3-9 shows the locations of areas where there is a head reversal between the Congaree and the Tuscaloosa Formations (i.e., the latter's head is higher than the former's). This map shows that the head in the Tuscaloosa is higher than the head in the Congaree in a broad area within about 10 kilometers

of the Savannah River and Upper Three Runs Creek. The head in the Congaree is higher than that of the Tuscaloosa in an area surrounding M-Area and in the vicinity of Par Pond.

A more detailed discussion of the hydrostratigraphic units and their head relationships across the entire site and in specific areas is given in Appendix F and in Du Pont (1983c).

L.3.5 Severe weather

The types of severe weather that might affect the cooling-lake operation are heavy precipitation and extreme winds.

The strongest winds in the SRP area occur in tornadoes, which can have wind speeds as high as 116 meters per second. The next strongest surface winds occur during hurricanes. During the history of the Savannah River Plant, only Hurricane Gracie, in September 1959, had winds in excess of 34 meters per second. Occasional winter storms with winds as high as 32 meters per second have been recorded (Du Pont, 1982b). Thunderstorms can generate winds as high as 18 meters per second with stronger gusts. The fastest 1-minute wind speed recorded at Augusta between 1951 and 1980 was 28 meters per second.

Heavy precipitation can occur in the SRP area in association with either localized thunderstorms or hurricanes. The maximum 24-hour total was about 15.2 centimeters, which occurred during August 1964 and was associated with Hurricane Cleo.

Severe weather values were used as design bases in Section L.2.3. More detailed severe weather information is presented in Section 3.5.3.

L.3.6 Ecology

The natural areas that could be affected by the construction and/or operation of the proposed cooling lake include Steel Creek, the Steel Creek corridor, the Savannah River swamp (including the Steel Creek delta), and the Savannah River. Section 3.6 and Appendix C contain baseline descriptions of the ecology of these areas. This section summarizes the major points in those descriptions; it emphasizes those environments that would be affected by this cooling alternative.

L.3.6.1 Terrestrial ecology

L.3.6.1.1 Vegetation

The preferred alternative would impact plant communities in two wetland areas: (1) those associated with the Steel Creek corridor from Road B to the delta, and (2) those associated with the Steel Creek delta and that portion of the swamp near the confluence of Steel Creek with the Savannah River. The

structure and species composition of these areas reflect not only the heterogeneity of the physical environment but also the impacts of earlier reactor operations.

The upland areas that would be inundated by the lake consist almost entirely of coniferous forest. Some areas contain almost pure stands of pine and others include an admixture of hardwood species.

Steel Creek corridor

The vegetation of the Steel Creek corridor, which is classified as palustrine wetland (Cowardin et al., 1979), varies markedly above the delta (Figure C-3). More than 85 species of plants representing 50 families were listed from this area in the summer of 1981 (Appendix C). This parcel consists of aquatic beds, emergents, scrub-shrub wetland, and forested wetland (Section 3.6.1.2.1).

Steel Creek delta

The Steel Creek delta contains 10 vegetative associations and four zones differentiated by the degree of prior reactor discharges of thermal effluent (Figure C-4). Impacted zones that have experienced structural reductions of the vegetative canopy include deepwater habitats and the deltaic fan. Bottomland hardwoods and deepwater and upland habitats comprise the nonimpacted zones. Since the shutdown of L-Reactor in 1968, vegetative recovery has varied according to the hydrologic regime (Figure C-4). Figure C-5 shows the distribution of the principal plant communities of the delta.

L.3.6.1.2 Wildlife

The abundance and diversity of wildlife that inhabit the Savannah River Plant reflect the interspersed and heterogeneity of the habitats occurring there. Emphasis has been given to those fauna that inhabit Steel Creek and the Savannah River swamp. No species have been found in the Steel Creek system that have not been found elsewhere on the SRP site.

Amphibians and reptiles

Because of its temperate climate and the variety of aquatic habitats, the SRP site contains a diversified and abundant herpetofauna. Species include 17 salamanders, 26 frogs and toads, 10 turtles, 1 crocodilian, 9 lizards, and 31 snakes that have zoogeographic ranges that include the Savannah River Plant (Conant, 1975). The ranges of many other species are peripheral to the Plant, and they could also occur on SRP lands. Gibbons and Patterson (1978) provide an overview of the herpetofauna, including the abundance and distribution of peripheral species. The endangered American alligator, which occurs in the area, is discussed in Section L.3.6.1.3.

Birds

Birds of the Steel Creek ecosystem were studied in the summer of 1981. A total of 1062 birds representing 59 species was tabulated during the summer survey; these species presumably breed locally. The white-eyed vireo was the most abundant species based on all census techniques, followed closely by the Carolina wren (Smith, Sharitz, and Gladden, 1981).

Because of the interspersed habitats and isolation from public hunting, the Steel Creek delta and Savannah River swamp provide an important sanctuary and refuge for regional waterfowl. Based on ground counts and aerial surveys, nine species of waterfowl have been observed in the Steel Creek delta area. The mallard and wood duck were the most predominant species of waterfowl; both used the Steel Creek delta extensively for roosting and feeding.

The endangered wood stork, which occurs in the area, is discussed in Section L.3.6.1.3.

Mammals

The Savannah River Plant includes zoogeographic ranges of more than 40 species of mammals, including the muskrat and black bear, which are known to occur near Steel Creek.

The short-tailed shrew, the least shrew, and the southeastern shrew were the most frequently captured small mammals during recent field investigations. The Steel Creek delta provides habitat for the rice rat, and probably for the eastern woodrat and the hispid cotton rat. The gray squirrel, the fox squirrel, and the southern flying squirrel were common in the upland and lowland forests along Steel Creek. Large mammals such as the feral pig and the white-tailed deer were common on the Steel Creek floodplain and delta. Other inhabitants of the floodplain and delta included the raccoon, the opossum and the gray fox. Beaver signs were common along the length of Steel Creek.

L.3.6.1.3 Threatened and endangered species

The American alligator and the wood stork are the only species listed as "endangered" by the U.S. Fish and Wildlife Service (USDOI, 1983, 1984) that have been identified in the area. No plant species with protective status has been found. No "critical habitat," as defined by the U.S. Fish and Wildlife Service, exists on the Savannah River Plant.

American alligator

Listed federally as endangered (USDOI, 1983), the alligator is common locally and breeds in Par Pond, in the Savannah River swamp (Gibbons and Patterson, 1978; Murphy, 1977), and along Steel Creek. The ecology of this species has been examined intensively on the Savannah River Plant. Early studies (Freeman, 1955; Jenkins and Provost, 1964) indicated that the alligator has always been a resident of the area. Its abundance probably increased greatly after the SRP was closed to the public in the early 1950s.

More recent studies of the alligator in the Steel Creek ecosystem were begun in 1981 (Smith, Sharitz, and Gladden, 1981, 1982a,b). These investigations have confirmed that alligators have utilized the Steel Creek ecosystem from the L-Reactor outfall to the Steel Creek delta and swamps, including other areas near Steel Creek such as Carolina bays, backwater lagoons, and beaver ponds. The population of alligators in the Steel Creek ecosystem was estimated to range between 23 and 35 individuals in 1981 and 1982 (Smith, Sharitz, and Gladden, 1982b). Sex ratio and size data suggest a higher reproductive potential in Steel Creek than is known for Par Pond, where nearly 80 percent of the adults are males (Murphy, 1977).

Studies of the wintering behavior and movements of alligators in the Steel Creek ecosystem were initiated in 1981 using radiotelemetry (Smith, Sharitz, and Gladden, 1982a). Generally, it was found that alligators on the Savannah River Plant do not utilize over-wintering dens, but remain active whenever winter temperatures are suitable. Several alligators moved between the lagoons near S.C. Highway 125. Individuals also utilized the swamp forest below the Steel Creek delta (Smith, Sharitz, and Gladden, 1982b). No alligator nests have been located in the Steel Creek system since 1981.

Based on the preferred cooling-water alternative (i.e., a 1000-acre lake), DOE prepared a new Biological Assessment and provided it to FWS (Sires, 1984b). This assessment included a March 1984 aerial survey of the proposed lake area, which contains marginal habitat for the alligator. Only one alligator was located in this area. The lake is expected to provide more suitable habitat than that currently in this area of Steel Creek, particularly in the portion that is maintained below 32.2°C; the critical thermal maximum for alligators is 38°C.

Wood stork

Recently listed as endangered by the U.S. Fish and Wildlife Service (USDOL, 1984), the wood stork uses the Steel Creek delta as one of its feeding grounds. A total of 102 individuals was observed feeding on or near the Steel Creek delta in late June to early July 1983. The maximum number of observations throughout the SRP swamp during this same period was 478 (Smith, Sharitz, and Gladden, 1983). The delta of Beaver Dam Creek also provides important feeding habitat for wood storks.

A recent Biological Assessment on the wood stork was submitted to FWS for their consideration (Sires, 1984a). The assessment concluded that the proposed L-Reactor operation and 1000-acre lake construction and operation would not jeopardize the continued existence of the wood stork.

These species and those listed by the State of South Carolina and the U.S. Fish and Wildlife Service as endangered, threatened, or of "special concern" are discussed in greater detail in Appendix C.

L.3.6.2 Aquatic ecology

L.3.6.2.1 Aquatic flora

Approximately 400 species of algae have been identified from the Savannah River near the Savannah River Plant (Patrick, Cairns, and Roback, 1967). Aquatic macrophytes in the river, most of which are rooted, are limited to shallow areas of reduced current and along the shallow margins of tributaries.

In the SRP streams that receive thermal effluents, the flora is sparse, reflecting the influence of high flow and elevated (greater than 40°C) water temperatures. In these streams, thermophilic bacteria and blue-green algae thrive (Gibbons and Sharitz, 1974).

A deepwater zone occurs where the main flow of Steel Creek courses toward the Savannah River. In this area, the vegetation is currently dominated by submergent and emergent macrophytes. Patches of duckweed occupy mats of submerged vascular plants such as hornwort and parrotfeather. Where the water flow is slow moving, smartweed forms dense colonies (Smith, Sharitz, and Gladden, 1981).

L.3.6.2.2 Aquatic fauna

Aquatic invertebrates

Shallow areas and quiet backwaters and marshes of the Savannah River near the SRP site support a diverse aquatic invertebrate fauna. However, the bottom substrate of most open portions of the river consists of shifting sand that does not provide the best habitat for bottom-dwelling organisms (Appendix C). The faunal composition now present reflects earlier impacts of dredging and polluted water conditions from which the community has not yet completely recovered.

The macrobenthic invertebrate drift communities in the river and SRP canals and creeks (including Steel Creek) are dominated by true-flies (particularly chironomids), which is typical of most riverine systems (see Appendix C). The attached invertebrate communities on wood substrate and macrophytes in Steel Creek are believed to be highly productive.

Mollusks, such as snails and clams, are an important component of the Savannah River invertebrate community (Patrick, Cairns, and Roback, 1967). The Asiatic clam, Corbicula, is found in the Savannah River, larger tributary streams in the vicinity of the SRP, and most thermally affected habitat on the SRP.

Fish

The Savannah River and its associated swamp and tributaries are typical of southeastern coastal plain rivers and streams, and support a diverse fish fauna (Appendix C). The diversity and abundance of fish in the thermally affected streams are high only during periods of reactor shutdown (McFarlane, 1976). In addition, the fauna upstream of the thermal effluents is depauperate in both numbers and diversity. With the exception of the mosquitofish, few fish live in the SRP thermal streams when heated effluent is present. During reactor shutdown, the streams return to ambient temperature and are invaded quickly by many fish from adjacent nonthermal areas. The diversity and abundance of species in the headwater tributaries of Four Mile Creek and Pen Branch upstream from reactor thermal effluents are reduced greatly in contrast to comparable areas in Upper Three Runs Creek or Steel Creek (McFarlane, 1976). Collection efforts have revealed that the first- and second-order tributaries of these streams have a low diversity of fish.

Fish population studies conducted in the Steel Creek swamp system (Appendix C) indicate a high species diversity. Fish of all sizes were collected in the swamp and a wide range of sizes was collected for most species. The collections were representative of both relative abundance and species composition of the swamp fish community. A total of 5313 fish representing 55 species was collected from the Steel Creek river-swamp from November 1981 through July 1982.

The high diversity of fish species is the result of the wide array of habitat types and niches available within the creek-swamp environment. The greatest abundance and diversity of fish occurred in deepwater areas where the tree canopy was eliminated during previous reactor operations, and the vegetation currently is dominated by submergent and emergent macrophytes. Fewer fish species and small numbers were collected in the reaches of Steel Creek that will be inundated by the cooling lake, compared to collections in the delta and swamp.

The use of the Steel Creek delta-swamp area by anadromous fish species (e.g., American shad and blueback herring) was minimal during 1982, although some American shad and blueback herring spawned near the mouth of Steel Creek that year. There was greater utilization of the Steel Creek delta-swamp by adults of the species in 1983 than in 1982. Also, two striped bass were collected in the delta-swamp area in 1983, while none were found the previous year. With the exception of the American eel, no migratory fish have been observed to utilize the upper reaches of Steel Creek that will be inundated by the cooling lake or will be isolated above it.

Recent studies have shown that Steel Creek contained numerous fish larvae, predominantly minnows, yellow perch, sunfish, and bass. Many blueback herring eggs were also collected. When compared to 19 other creeks, Steel Creek ranked eighth in larval density of all species combined.

L.3.6.2.3 Threatened and endangered species

Two aquatic species listed as "endangered" by the Federal Government (USDOI, 1983) and/or the State of South Carolina (Forsythe and Ezell, 1979) are known to occur on or in the vicinity of the SRP. These are the shortnose sturgeon (Federal list) and the brother spike mussel (State list).

The shortnose sturgeon is found only on the east coast of North America in tidal rivers and estuaries. Prior to 1982, this species had not been reported in the middle reaches of the Savannah River in the vicinity of SRP. However, in 1982 and 1983, shortnose sturgeon larvae were collected in the river near the site, indicating that spawning occurred in the river. The only known occurrence of the brother spike mussel in the Savannah River occurred in 1972, approximately 15 river miles downstream from the mouth of Steel Creek.

L.3.7 Radiocesium and radiocobalt in Steel Creek and the Savannah River

L.3.7.1 Radiocesium

Since 1955, approximately 560 curies of radiocesium have been discharged to onsite streams of the Savannah River Plant. Of this total, about 284 curies were released to Steel Creek. Annual releases ranged from about 0.02 curie since 1978 to a maximum of about 53 curies in 1964. The primary source of this radiocesium was leaking failed fuel elements stored in disassembly basins in the P- and L-Areas. Water was released routinely from these basins to maintain the clarity needed for underwater manipulation of irradiated fuel elements, hence the release of radiocesium (with a cesium-134-to-cesium-137 ratio of about

1:20).* A sharp decrease in the release of cesium-137 to Steel Creek occurred in the late 1960s and early 1970s when (1) the P-Area basin was fitted with sand filters and water was demineralized before its release; and (2) the leaking fuel elements were removed to an environmentally safe storage area.

After the radiocesium was discharged from the P- and L-Areas to Steel Creek, it became associated primarily with the silts and clays in the Steel Creek system. Here the sediments and associated cesium-137 were subjected to continued resuspension, transport, and deposition by the flow regime in the creek.

In addition to SRP releases, nuclear weapons testing since the mid-1940s deposited approximately 2850 curies of radiocesium on the Savannah River watershed, including about 80 curies on the Savannah River Plant.

The subsections that follow describe radiocesium in Steel Creek and Savannah River sediments, the radiocesium inventory in Steel Creek, cesium-137 in biota, and cesium-137 in water. Appendix D provides more details.

L.3.7.1.1 Cesium in sediments

Radiocesium, primarily cesium-137 in Steel Creek, is predominantly associated with the bottom sediments. The principal mechanisms for this association are (1) cation exchange with kaolinite and gibbsite clay minerals; (2) sorption on minerals; and (3) chelation with naturally occurring organic material. A distribution coefficient ($K_d = 3960$) measured for sediments from Four Mile and Steel Creeks (Kiser, 1979) demonstrates the affinity of cesium-137 for the sediments in the Steel Creek system.

Soil cores collected in 1974 at two transects in Steel Creek between Road A and the swamp showed that 69 percent of the radiocesium was located within the upper 20 centimeters of sediment and 86 percent was confined to the upper 40 centimeters. More extensive detailed coring conducted in 1981 at 12 transects between the Steel Creek delta and P-Reactor generally confirms the 1974 results; about 61 percent of the radiocesium was found in the upper 20 centimeters, and 83 percent in the upper 40 centimeters (Du Pont, 1982b; Smith, Sharitz, and Gladden, 1982a). Sediment samples taken in 1981 from the center of the creek had markedly lower radiocesium concentrations than the sediments near the edges of the floodplain. The radiocesium is predominantly associated with smaller soil particles (Table L-3).

*For convenience, the radiocesium will usually be described as cesium-137, when the presence of both cesium-134 and -137 is implied.

Table L-3. Range of cesium-137 concentrations
(pCi/g dry weight) of soil types
in Steel Creek, 1981

Soil type ^a	Number of samples	Percentage	Concentrations	
			Mean	Standard error
1 (clay)	101	19	137	20
2	108	21	80	16
3	127	24	39	7
4	83	16	55	12
5 (sand)	106	20	17	3

^aSoil samples were graded visually from 1 to 5, according to their "average" particle size; samples with the highest clay content are type 1 and those with the least clay and silt (i.e., predominantly sand) are type 5 (Smith, Sharitz, and Gladden, 1981).

L.3.7.1.2 Cesium in the Savannah River

Turbulence in the Savannah River generally keeps fine soil particles in suspension. These particles are deposited where the river velocity and turbulence are low (such as inside river bends, downstream from obstructions, in oxbow lakes, and on the floodplain), and where flocculation occurs in the estuary below River Mile 40. Riverbed sediments upstream from the Savannah River Plant normally have about 1 picocurie per gram or less of radiocesium (Du Pont, 1982b).

In 1974, riverbed sediments downstream of the Savannah River Plant had concentrations of about 2 picocuries per gram near the U.S. Highway 301 bridge and 6.5 picocuries per gram at the South Carolina Highway 119 bridge near Clyo, Georgia. Studies performed in 1978 showed that the radiocesium concentrations were about 0.6 picocurie per gram at the control station above the Savannah River Plant and less than 0.8 picocurie per gram at sampling stations between Little Hell Landing and the Highway 301 bridge (Du Pont, 1982b).

L.3.7.1.3 Cesium-137 in biota

Vegetation samples were collected at various times from 1970 to 1981 at 10 transects in Steel Creek between the delta and L-Reactor. Samples were also collected at 10 transects in the Savannah River swamp and Creek Plantation

Swamp. The average radiocesium concentrations in swamp vegetation are generally less than those in vegetation from the creek. The total radiocesium inventory in Steel Creek vegetation is about 0.4 curie (Du Pont, 1982b).

The concentration of radiocesium in wildlife is generally not high in Steel Creek, the Savannah River swamp, and Creek Plantation Swamp; concentrations in Savannah River fish are lower than those measured in fish from Steel Creek (Du Pont, 1982a). Additional details are provided in Appendix D.

L.3.7.1.4 Cesium-137 in water

Monitoring in the Savannah River by the Savannah River Plant shows that the concentration of radiocesium in river water has been very low in the past several years. From 1979 through 1982 the mean concentration of cesium-137 at the U.S. Highway 301 bridge was 0.08 picocurie per liter and near the limit of detection at the control station above the Plant (Du Pont, 1980b, 1981b, 1982c, 1983b). For the second quarter of 1983, measurements of the radiocesium in the potable (finished) water at the North Augusta, Beaufort-Jasper, and Cherokee Hill water-treatment plants averaged 0.006, 0.028, and 0.033 picocurie per liter, respectively. During this monitoring period, the radiocesium concentrations in the potable water were found to vary inversely with river flow (Kantelo and Milham, 1983). In 1982, the monthly average cesium-137 concentration in Steel Creek at the Cypress Bridge (just upstream from the delta; see Figure D-3) was about 3 picocuries per liter; this concentration is about the same as those measured during the previous 5 years.

In November and December 1981, seven water samples from Steel Creek between Road A and the delta were analyzed for their cesium-137 (and potassium) content (Ribble and Smith, 1983). The concentrations ranged from 3.9 to 7.9 picocuries per liter and had a mean value of 5.3 picocuries per liter (with a mean potassium concentration of 1.0 milligram per liter). About 84 percent of this value was associated with the dissolved fraction and 16 percent with the suspended solid fraction. Similarly, Shure and Gottschalk (1976) found that about 20 percent or less of the cesium-137 in water samples from Lower Three Runs Creek was associated with the suspended solid fraction.

More recently, Hayes (1983) reported the results of cesium-137 measurements in Steel Creek made from April through August 1983. During this period, the average transport of cesium-137 was 3.2 ± 1.5 millicuries per week at Cypress Bridge. From this basis, the annual transport would be about 0.17 ± 0.08 curie per year. These measurements indicated that about half the transported cesium-137 was due to remobilization from the creek floodplain system above L-Reactor.

Hayes (1983) also reported that the water that enters Steel Creek from L-Area, Meyer's Branch (the principal tributary of Steel Creek), and as local rainfall contained cesium-137 concentrations of less than 1 picocurie per liter. However, the measured cesium-137 concentrations at Cypress Bridge averaged about 3.7 ± 0.6 picocuries per liter during the April through August 1983 study period. Hayes contends that the cesium-137 concentrations are governed by a reequilibration process between the water and the cesium in the creekbed and floodplain sediments, because he could find no correlation during this period between cesium concentration and creek flow rate, or such other

variables as suspended solid or tritium concentrations in Steel Creek water or rainfall in the area. Hayes concluded that the creekbed and floodplain sediments could support cesium concentrations as high as about 11 picocuries per liter at equilibrium, and that the lower concentrations (3.7 picocuries per liter) were probably due to insufficient time for the process to reach equilibrium between the water and the cesium-laden sediments. The travel time for water from L-Area to Cypress Bridge is less than 1 day.

L.3.7.2 Radiocobalt

Along with the radiocesium, small amounts of radiocobalt, 66 curies (Du Pont, 1983a), formed by neutron activation of stainless steel and dissolved in the fuel element storage basin water, were discharged to onsite streams. Of this total, approximately 27 curies were released to Steel Creek. As a result of radioactive decay, a small amount, about 2.1 curies, remains in Steel Creek or Creek Plantation Swamp, or has been transported to the river in a manner similar to radiocesium. Further examination of cobalt has not been performed because the inventories in both Steel Creek and the Savannah River system are significantly less than the bounding cesium inventories (Du Pont, 1983a). Additional details can be found in Appendix D.

L.3.7.3 Radiostrontium

During earlier operations, L- and P-Areas released approximately 0.5 curie of strontium-89 and 40.8 curies of strontium-90 to Steel Creek (Ashley, Zeigler, and Culp, 1982). Because of the short half-life of strontium-89 (50.5 days), no measurable quantities are likely to exist in the creekbed sediments. Strontium-90 has a half-life of about 28 years. About 14.3 curies of strontium-90 have been lost by radioactive decay. Based on ERDA (1977) and Marter (1974), another 20.8 curies have been transported to the Savannah River. Thus, about 5.7 curies of strontium-90 might still remain in the sediments of Steel Creek. Soil corings in Steel Creek at Road B and Cypress Bridge and near its mouth have detected strontium-90 concentrations ranging from 0.11-0.14 picocurie per gram in 1978 to 0.12-0.14 picocurie per gram in 1979. At the SRP control station, strontium-90 concentrations of soil samples were 0.06 picocurie per gram in 1978 and 0.14 picocurie per gram in 1979 (Ashley et al., 1982). These soil coring studies suggest that the inventory might be much less than 5.7 curies. It is not surprising that most of the strontium-90 has been transported from Steel Creek, because the kaolin clay particles of the creekbed sediments have little sorptive capacity for strontium. The distribution coefficient for strontium-90 in SRP kaolinitic soils might be as low as 20 (Oblath, Stone, and Wiley, 1983), which is at least 35 times less than that for cesium-137.

L.4 CONSEQUENCES OF OPERATION

L.4.1 Normal operation

L.4.1.1 Nonradiological impacts

L.4.1.1.1 Water use and quality impacts

L.4.1.1.1.1 Surface-water impacts

The surface-water usage would be the same as in the reference case, with a withdrawal of 11 cubic meters per second from the Savannah River. The thermal discharge from L-Reactor would flow into the 1000-acre lake; the discharge from L-Reactor and from the lake would be about 11 cubic meters per second. Table L-4 lists the estimated downstream temperatures in Steel Creek below the embankment for the summer, spring, and winter.

Table L-4. Temperatures (°C) downstream in Steel Creek below the 1000-acre lake^a

Location	Summer ^b	Spring ^c	Winter ^c
Discharge temperature ^d	31	26	17
Road A	31	26	17
Swamp	31	25	15
Mid-swamp	30	22	13
Mouth of creek at river	30	22	13

^aAssumes power reduction when necessary to meet water-quality standards.

^bBased on worst 5-day meteorological conditions (July 11-15, 1980) and estimated operating power of reactor. Five-day worst-case meteorological conditions provide the basis for a conservatively high estimate of discharge and downstream temperatures that are likely to result from the implementation of a thermal mitigation alternative. The selection of 5-day worst-case meteorology is also based on a typical cycle of consecutive meteorological conditions; it is considered to be representative of extreme temperatures for which the maintenance of a balanced biological community can be measured under Section 316(a) of the Federal Water Pollution Control Act.

^cBased on 30-year average values for meteorological conditions and actual power of an operating reactor. Summer average temperatures have been included to show the discharge and Steel Creek temperatures that could be expected if significant temperature excursions above and below average did not occur.

^dThe temperature entering Steel Creek from the lake.

Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp, and the mouth of Steel Creek would be within about 1°C of ambient. In the spring, water temperatures at the Steel Creek delta would be

3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions do not pose any adverse impacts to aquatic and semiaquatic biota. In the winter however, projected temperatures at Road A and points downstream would be 7°C to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in a gradual heat loss in this area, which would minimize any cold shock effects. This alternative would not adversely impact access to, and the spawning of riverine and anadromous fishes in, the Savannah River swamp below the Steel Creek delta.

The habitat inundated by the 1000-acre lake alternative would include 225 acres of wetlands in the Steel Creek corridor. The lake would also inundate 775 acres of uplands. There would be minimal thermal impact on wetlands below the embankment. However, the flow rate would adversely impact between 215 and 335 acres of wetlands in the Steel Creek delta and swamp that provide foraging habitat for the endangered wood stork and the endangered American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. These wetlands are classified as Resource Category 2 by the U.S. Fish and Wildlife Service. This resource category and its designation criteria include "high value for evaluation species and scarce or becoming scarce." The mitigation planning goal specifies that there be "no net loss of inkind habitat value" (USDOI, 1981).

Wastewater and sanitary discharges would be similar to those associated with the reference case; no impacts from these discharges are anticipated.

No appreciable change is expected in the chemical characteristics of the effluent as the result of its passing through the lake, except that about 6 percent of the suspended solids would be removed from the river water by the 186-Basin and the impoundment.

Criteria of embankment stability design have established that seepage of water is a critical consideration. Therefore, the embankment will be designed so that total permanent seepage loss through the embankment abutments and foundation will be limited. To ensure positive restriction through the foundation of the embankment, an impervious soil or grout cutoff trench will be constructed to the maximum depth that is economically feasible and tied into the abutments. Seepage through the embankment will be slight, because the embankment will consist of three or four zones.

Due to the sandy soil in the area of the natural saddle, some seepage could occur from the lake to Pen Branch. A cut-off wall would be constructed if seepage became a problem.

L.4.1.1.1.2 Ground-water impacts

The use of ground water for L-Reactor would be 0.94 cubic meter per minute). This withdrawal is estimated to have minimal impacts.

Impounded water for a cooling lake would cause a local ground-water mound in the water-table aquifer which would tend to increase the travel time from the L-Reactor seepage basin to seepage springs near the lake's shore from 18 to 21 years. This effect of the lake would dissipate with depth and would be expected

to have a small effect on water levels in the McBean Formation. The green clay is an important confining unit separating the McBean from the underlying Congaree Formation. It would prevent the increased head associated with a cooling lake from impacting the head differential between the Tuscaloosa and Congaree Formations. It is also an important barrier to the migration of contaminants from near-surface to lower hydrostratigraphic units. In the Separations Areas and near the Central Shops, the green clay (about 2 to 3 meters thick) supports a head difference of about 21 to 24 meters between the McBean and Congaree Formations. Based on water samples obtained for tritium analysis from the Congaree near the H-Area seepage basin, the green clay has effectively protected the Congaree ground water from contamination seeping into the ground (Marine, 1965). In the L-Area, the green clay is about 7 meters thick. At the Par Pond pumphouse, along the strike of the McBean and Congaree Formations, the green clay also supports a large head difference; the water pumped from the Congaree Formation shows no evidence of tritium contamination, even though tritium concentrations in Par Pond were measured at 27,000 picocuries per liter.

L.4.1.1.2 Ecological impacts

The operation of L-Reactor with the preferred cooling alternative would have some impacts on the ecology of the Savannah River, Steel Creek below and above the lake, the Steel Creek corridor, and the Savannah River swamp (including the Steel Creek delta). In addition, a portion of the lake itself would be affected by the heated water discharged into it. This section describes operational impacts on each of these natural areas.

L.4.1.1.2.1 Savannah River

The impacts of impingement and entrainment would be the same as those of the direct-discharge alternative (reference case). An average of 16 fish per day (5840 fish per year) would be impinged on the cooling-water intake screens, and approximately 7.7×10^6 fish eggs and 11.9×10^6 fish larvae would be lost to entrainment through the plant.

Thermal impacts on the biota in the river would be minimal because water temperatures would be very close to ambient at the point the discharge flow enters the river. There would be a zone of passage for the movement of fish up and down the river past the SRP site.

L.4.1.1.2.2 Steel Creek downstream from the lake

Projected water temperatures in the summer (5-day, worst-case) at the Steel Creek delta, mid-swamp and the mouth of Steel Creek would be within about 1°C of ambient (see Table 4-31). In the spring, water temperatures at the Steel Creek delta would be 3°C above ambient. Water temperatures would be near ambient at the mouth of Steel Creek. These conditions would not pose any adverse impacts to aquatic and semiaquatic biota. In the winter, however, projected temperatures at Road A and points downstream would be 7°C to 9°C above ambient. These warmer conditions could concentrate fish at the mouth of Steel Creek. Reactor shutdowns during the winter would result in gradual heat loss in this area which would minimize any cold shock effects. This alternative would not adversely impact access to and the spawning of riverine and anadromous fishes in the Savannah River swamp below the Steel Creek delta.

There would be minimal impacts in Steel Creek below the embankment. However, the flow of discharge water would have adverse impacts on between 215 and 335 acres of wetlands in the Steel Creek delta and swamp. This area, which is dominated by forested (45 percent) and scrub-shrub (36 percent) wetlands, provides foraging habitat for the endangered wood stork and American alligator. These wetlands also represent important feeding and roosting habitat for as many as 1200 mallard and 400 wood duck. A delta growth rate of about 1 to 2 acres per year is anticipated.

L.4.1.1.2.3 Steel Creek upstream from the lake

The embankment and cooling lake would prevent access by riverine and anadromous fish to about 100 acres of wetlands along Steel Creek above L-Reactor. However, the only migratory fish in this reach of Steel Creek would be the American eel. Also, access to Meyers Branch would not be affected by the embankment.

Preliminary results of investigations in Upper Steel Creek indicate that the macroinvertebrate community there is self-sustaining and therefore unlikely to undergo significant changes as a result of the creation of the 1000-acre lake. Sixteen species of fish have also been collected in this reach of Steel Creek during two recent surveys. Most of the species are small fish that prefer stream habitats. However, all but one of the species collected have been reported in thermal refugia (backwater or tributary stream areas) peripheral to reactor effluent streams on SRP; therefore, the fish populations in Upper Steel Creek could be capable of maintaining their present status in the 3- to 4-kilometer reach that would be isolated above the cooling lake when the reactor is operating. There would undoubtedly be shifts in patterns of relative abundance. For example, the thermally tolerant mosquitofish would probably increase in abundance and species that prefer pond habitats could thrive in the upper portions of the lake, where temperatures would be moderated by the inflow from Steel Creek.

L.4.1.1.2.4 Cooling lake

One of the principal concerns regarding the impacts of the operation of a 1000-acre cooling lake is the types of biological communities that would develop in the lake. Of particular importance is the requirement, pursuant to Section 316(a) of the Clean Water Act, for establishing and maintaining "balanced indigenous populations" in at least a portion of this water body. DOE has committed to operating L-Reactor in such a manner that such balanced communities would be maintained. Present estimates are that about 50 percent of the lake (about 500 acres) would have water temperatures below 32.2°C during the summer, which would be the most critical period for most aquatic organisms. During the remainder of the year, maximum water temperatures would be less critical, but nonetheless important.

Precisely describing in advance the aquatic communities that would develop in the cooling lake is difficult because:

1. Every new impoundment is unique because its physical and, particularly, its chemical characteristics depend on such factors as: the topography of the inundated area, the chemistry of the soil, the nature and extent of submerged vegetation, the internal pattern of circulation, the

source and quality of inflowing water, the exchange rate, mixing characteristics, etc. The biological communities that develop depend on the physical and chemical environment and on the types and numbers of organisms that move in to occupy the new water body and the speed and order in which they do so. The combinations of these important physical, chemical and biological factors are different for each impoundment that is created. Accordingly, the ecosystem that develops in each is also unique and changes slowly to resemble that in a natural water body of similar characteristics.

2. An artificial thermal regime would be present in this environment.

However, an indication of what might reasonably be expected can be obtained from analyzing the results of the biological studies of Par Pond and other thermally impacted water bodies on SRP. The following sections make this analysis for each of the major groups of organisms that would comprise the balanced aquatic community that would develop in the 1000-acre cooling lake. Due to the thermal regime in part of the lake, it is possible that Aeromonas bacteria could occur.

Fish

The inundation of this 7-kilometer reach of Steel Creek would create a lake environment where a flowing stream now exists. Accordingly, the productivity in this area would greatly increase because the cooling lake would be able to support many more fish than the existing reach of Steel Creek that it would replace. As explained below, the nature of the fish community that will develop can be predicted only in general terms, based on observations of the communities in existing SRP thermal ponds.

For example, the Par Pond system shows a generalized pattern of increasing fish abundance and diversity from Pond C, which is affected more heavily by heated discharges, to Par Pond, which receives less thermal impact. The structure of the fish communities in the two ponds is primarily determined by water temperature, although other factors such as habitat size and characteristics, historic introduction of species, and/or recolonization from the impounded drainage system are also important. Table L-5 lists the fish species found in these two cooling ponds and their relative abundance. Pond C contains fewer fish species (18), of which only two (largemouth bass and bluegill) make up more than 95 percent of the game fish species in this pond (Clugston, 1973). Par Pond contains 29 species of fish, seven of which are abundant; the fish community in Par Pond can be considered "balanced" and self-sustaining and, although the environment is thermally stressed, the community is not dominated by pollution-tolerant species. The standing crop of fishes in Par Pond was similar to that in nearby reservoirs in South Carolina (Clugston, 1973).

It is anticipated that the 1000-acre lake will contain a balanced fish community similar to that present in Par Pond. Also, other species from the Savannah River can enter the lake as eggs, larvae or fry in the cooling water that passes through the plant when thermal stress is low. The exact balance of species that will develop cannot be predicted accurately. However, based on Par Pond, it is anticipated that a bass-bluegill-sunfish dominated community will develop. Clugsten (1973) found that the size of the largemouth bass population in Par Pond is greater than that in other South Carolina reservoirs. This

Table L-5. Fishes of the Par Pond reservoir system

Species	Pond C	Par Pond
Mosquitofish	A	A
Bluegill	A	A
Red-breast sunfish	C	A
Largemouth bass	C	A
Redfin pickerel	R	R
Yellow bullhead	R	+
Lake chubsucker	R	A
Golden shiner	R	+
Black crappie	+	A
Flathead catfish	+	+
Swamp darter	+	+
Redear sunfish	+	+
Dollar sunfish	+	C
Warmouth	+	C
Pygmy sunfish	+	+
Pirate perch	+	
Blueback herring	+	R
Gizzard shad	+	R
Brook silversides		A
Yellow perch		R
American eel		+
Spotted sucker		+
Coastal shiner		+
Brown bullhead		+
Bowfin		R
Chain pickerel		C
Flat bullhead		+
Channel catfish		+
Tadpole madtom		+
Spotted sunfish		+

A = Abundant

C = Common

R = Rare

+ = Abundance uncertain

species occurs in a density of about 20 individuals per acre in Par Pond (Gilbert and Hightower, 1981). Accordingly, the numbers of this species that could be supported in the 500 acres of the 1000-acre lake to be maintained below 32.2°C is estimated to be 10,000. This is well above the level of 500 adult breeding individuals that has been identified as the minimum required for maintaining long-term balanced populations of these species. The size of the unstressed zone with the 1000-acre lake is sufficient to support a self-sustaining fish community made up of many other species such as sunfish, crappies, and silversides which are abundant in Par Pond. In addition, the mosquitofish is expected to be numerically abundant both in the stressed and unstressed lake areas.

The normal seasonal cycles evident in natural unstressed water bodies will be modified somewhat by the input of heated water to the cooling lake. Preliminary data from studies in Par Pond have shown that some fish species might spawn and produce fry successfully during the winter months rather than only during their normal reproductive season. Also, growth rates of fishes can be expected to be greater because of the absence of cold-weather dormant periods. Under the proposed operation plan, the fish would have large areas to seek optimum water temperatures year-round. They would be able to avoid hot, stressful zones during the summer and to seek out warmer water in the winter when the reactor is in operation. This artificial thermal regime has not prevented the establishment of a balanced fish community in Par Pond, and it is expected that a fish community of similar structure and function would develop in the 1000-acre lake. The stocking of certain species could also be a method to enhance the establishment of a balanced biological community.

Benthic macroinvertebrates

It is anticipated that a balanced community of benthic macroinvertebrates will be developed and maintained in a portion of the cooling lake. Based on observations in Par Pond and the other thermally stressed SRP ponds, three different temperature zones can be identified:

- Zone I (less than 32.2°C)--Balanced benthic community
- Zone II (32.2°C to 35°C)--Stressed community
- Zone III (35°C to 37°C)--Depauperate populations

Table L-6 lists the common invertebrates that might be found in these zones.

Zone I. Balanced benthic community. In this area, water temperatures will not exceed 32.2°C, even in the summer. A balanced biological community could develop in this zone. It would probably resemble the benthic assemblage present in the warm (but not hot) areas of Par Pond (Table L-6). Such assemblages are characterized by high diversity and density. They are not dominated by stress-tolerant taxa but resemble communities in other SRP areas that never received heated effluent or that are post-thermal. These groups of invertebrates can support organisms at higher trophic levels, including a range of fish species.

Another important criterion for the development of a balanced invertebrate community would be the availability of adequate shallow-water areas with suitable sediment. It is anticipated that such areas will be present along most of the shoreline of the cooling lake, particularly in any embayments or backwaters. There will be adequate dissolved oxygen in these critical habitat areas

Table L-6. Common macroinvertebrates that might be found in thermal zones in 1000-acre lake

Zone I. Water temperatures less than 32.2°C ("balanced")

Turbellaria (flatworms)

Nematoda (Nematodes)

Oligochaeta (Segmented worms), mainly Noididae

Hirudinea (leeches)

Mollusca

Gastropoda (snails)

Physella heterostropha (Say)

Helisoma trivolvis (Say)

Helisoma anceps (Marke)

Campeloma docuim (Say)

Gyraulus parvus (Say)

Pelecypoda (clams and mussels)

Sphaeriidae (Sphaerium)

Corbicula fluminea (Muller)

Anodonta imbecillus (Say)

Arthropoda

Amphipoda (Scuds)

Hyalella azteca (Saussure)

Acari (water mites)

Decapoda (crayfish)

Procambarus spp.

Insecta (Insects)

Ephemeroptera (Mayflies)

Caenis diminuta (Walker)

Callibaetis sp.

Odonata (Dragonflies and damselflies)

Celithemis spp.

Epicordulia princeps (Hagen)

Table L-6. Common macroinvertebrates that might be found in thermal zones in 1000-acre lake (continued)

Zone I. Less than 32.2°C ("balanced") (continued)

Erythemis simplicollis (Say)
Ladona deplamota (Pambur)
Pachydiplax longipennis (Burmeister)
Perithemis tenera (Say)
Tetragoneuria cynosura (Say)
Aphylla willamsoni (Gloyd)
Anax junius (Diurg)
Enallagma spp.
Ischnura spp.

Trichoptera (Caddisflies)

Oecetis spp.
Oxyethira spp.
Orthotrichia sp.
Cernotina spirata (Kris)
Agrypnia vestita (Walker)
Ptilostomis spp.

Megaloptera (fishflies and alderflies)

Chauliodes spp.
Sialis spp.

Lepidoptera (butterflies and moths)

Parapoynx sp.

Hemiptera (true bugs)

Trichocorixa sp.
Hesperacorixa sp.
Sigara spp.
Belostoma sp.
Ranatra buenoi (Hungerford)
Buenoa spp.
Gerris spp.
Metrobates sp.
Mesovelis sp.
Microvelis sp.

Coleoptera (Beetles)

Berosus spp.
Hydroporus spp.
Hydrovatus spp.
Tropisternus spp.

Table L-6. Common macroinvertebrates that might be found in thermal zones in 1000-acre lake (continued)

Zone I. Less than 32.2°C ("balanced") (continued)

Peltodytes spp.

Cymbiodyta spp.

Celina spp.

Diptera (True flies)

Tipulidae

Culicidae

Ceratopogonidae

Chironomidae

Ablabeskyia spp.

Larsia sp.

Procladius spp.

Labruridia spp.

Coryoneura sp.

Cricitopus sp.

Eukieffer sp.

Brilla sp.

Chironomus spp.

Cryptochironomus

Dicrotendipes spp.

Glyptotendipes sp.

Microtomadipes

Polypedilum spp.

Harnischia spp.

Phaenopsecta spp.

Pseudochironomus spp.

Rheotanytarsus spp.

Tanytarsus spp.

Chaoboridae

Chaoborus punctipennis (Sax)

Tabanidae

Chrysops spp.

Tabanus spp.

Table L-6. Common macroinvertebrates that might be found in thermal zones in 1000-acre lake (continued)

Zone II. Water temperatures 32.2°-35°C ("stressed")

Oligochaeta (segmented worms), mainly Naididae

Nematoda (Nematodes - roundworms)

Gastropoda (Snails)

Physella heterostropha (Say)

Helisoma trivolvis (Say)

Pelecypoda (clams and mussels)

Corbicula fluminea (Muller)

Amphipoda (scuds)

Hyalella azteca (Saussure) (questionable presence)

Acare (water mites)

Insecta (insects)

Ephemeroptera (Mayflies)

Caenis diminuta (Walker)

Odonata (Dragonflies and damselflies)

Erythemis simplicicollis (Say)

Pachydiplax longipennis (Burmeister)

Perithemis tenera (Say)

Enallagma spp.

Ischnura spp.

Trichoptera (Caddisflies)

Oecetis spp.

Hemiptera (true bugs)

Corixidae

Belostoma sp.

Coleoptera (Beetles)

Hydrophilidae

Dystiscidae

Diptera (true flies)

Table L-6. Common macroinvertebrates that might be found in thermal zones in 1000-acre lake (continued)

Zone II. 32.2°-35°C ("stressed") (continued)

Ceratopogonidae

Chironomidae

Ablabesmyia spp.
Procladius spp.
Labrundinia spp.
Cricotopus spp.
Dicrotendipes spp.
Polypedilum spp.
Tanytarsus spp.
Tanytarsini

Zone III. Water temperatures 35° to 37°C ("depauperate")

Some Oligochaeta (segmented worms)

Some Nematoda (Nematodes; roundworms)

within Zone I because the water temperatures will be lower, stratification of the water column will be less, and the distances from the stressed zones of accelerated organic decomposition will be greater.

Zone II. stressed community. Water temperatures in this area will range from 32.2°C to 35°C in the summer. The community structure will be intermediate in complexity between those in Zones I and III. The benthic populations will be self-sustaining and "balanced" but will be characterized by stress-tolerant organisms. A list of the dominant species expected within this zone is given in Table L-6. A large percentage of the species present in Zone I will also be represented here. The principal differences are that some more thermally sensitive forms will be excluded from Zone II and that the relative dominance of species will change. The majority of individuals should be present at depths between 1 and 3 meters. Below these depths, the oxygen concentration in the water becomes limiting. Only a few species (but many individuals each) can tolerate the low oxygen-anoerobic conditions that probably would be present at greater depths. If the water column is stratified, the benthic assemblage below the thermocline in Zone II could resemble the deepwater assemblages in most areas of Par Pond. Above the thermocline, the benthic assemblage would probably roughly resemble the fauna in Coleman's Cove, a thermally stressed area of Par Pond. Community functioning within this zone should resemble that in a balanced biological community (but with less species and linkages), unless the source of nutritive organic matter changes significantly (e.g., by an increase in the relative abundance of blue-green algae and a significant decrease in other rooted, floating, and emergent macrophytes), in which case the community structure would further degrade to more stress-tolerant forms.

The organisms in this benthic zone will be an important additional source of food for fishes in the 1000-acre lake, particularly during the periods when water temperatures fall and fish re-enter shoreline areas from which they were excluded during the warmest summer months.

Zone III. Depauperate community. The water temperatures in this zone are so high (35°C-37°C) that very few, if any, benthic invertebrates would survive. The food source would be different than in other areas of the cooling lake. Blue-green algae would be the dominant primary producer. This would further reduce the kinds and numbers of benthic consumers present, because very few forms can utilize blue-greens directly or indirectly. Table L-6 lists some taxa that could be present in this zone.

Plankton

Phytoplankton, periphyton and zooplankton populations that would develop in the 1000-acre lake will resemble those present in Par Pond and Pond C. Tables L-7, L-8, and L-9 list the species from these three groups that have been collected from the existing thermal ponds on SRP. The temperature regime within the cooling lake should be the principal factor that determines whether the new plankton community is most similar to one or the other of the existing environments. In those areas where summer water temperatures do not exceed 32.2°C, a balanced biological community of plankton will be present. This community will be similar to that in Par Pond, except that the continuous input of relatively nutrient-rich Savannah River water would make the 1000-acre lake more productive and more likely to develop nuisance algal blooms than Par Pond. However, the expected shorter retention time within the once-through system may partially or completely offset this potential. Also, the input of Savannah River water and water from Upper Steel Creek might also increase the species richness and diversity of the plankton community in the 1000-acre lake.

The seasonal effects on the plankton would primarily be an increase in primary production during the winter months when water temperatures in the coolant lake would be warmer than in ambient water bodies. This beneficial effect would be partially or completely offset in the warmest summer months by decreased production by useful species and augmented production by blue-green nuisance species. The blue-greens will be the dominant alga at water temperatures above about 37°C. Primary production by this group in the summer could result in large mats of organic material being carried into the non-thermally stressed zones and adversely affecting the populations of other organisms therein. Table L-10 summarizes the expected condition of the plankton community within various temperature zones in the 1000-acre lake. A balanced community can exist only where water temperatures do not exceed 32.2°C.

Macrophytes

The presence of macrophytes in the 1000-acre lake will be an important factor in the establishment and maintenance of a balanced fish community within this body of water. Based on observations in Par Pond, it is anticipated that a balanced vascular plant community will develop in some shoreline areas of the cooling lake where maximum water temperatures do not exceed 32.2°C. Very few plants will exist in areas of higher temperature. This can be seen clearly in Table L-11, which lists those vascular plant species present in Par Pond (moderately thermally stressed) and in Pond C (highly thermally stressed).

Table L-7. Phytoplankton collected from Pond C and Par Pond

Species	Pond C	Par Pond
Bacillariophyta		
<u>Achanthes linearis</u> (W. Smith) Grun.	X ^b	X
<u>Achanthes minutissima</u> Kutz.	X	X
<u>Asterionella formosa</u> Hassal.	X	X
<u>Atthea zachariasii</u> J. Brun.		X
<u>Caloneis</u> sp.	X	
<u>Cyclotella stelligera</u> Cleve and Grun.	X	X
<u>Cymbella minuta</u> Hilsc ex. Rabh.	X	X
<u>Eunotia pectinalis</u> (Kutz.) Rabh.	X	X
<u>Fragilaria crotonensis</u> Kitton	X	X
<u>Frustulia rhomboides</u> (Ehr.) Det.		X
<u>Gomphonema gracile</u> Ehr.		
<u>Gomphonema parvulum</u> Kutz.	X	
<u>Melosira ambigua</u> (Grun.) O. Miller	X	
<u>Melosira granulata</u> (Ehr.) Ralfs	X	X
<u>Melosira granulata</u> v. <u>angustissima</u> Mull.	X	X
<u>Navicula cryptocephala</u> Kutz.	X	X
<u>Navicula hustedtii</u> Krasske	X	
<u>Navicula</u> sp.		X
<u>Nitzschia acicularis</u> W. Smith	X	X
<u>Nitzschia denticula</u> Grun.		X
<u>Nitzschia dissipata</u> (Kutz.) Grun.	X	X
<u>Nitzschia holsatica</u> Hust.		X
<u>Nitzschia palea</u> (Kutz.) W. Smith	X(M) ^c	X
<u>Rhizosolenia eriensis</u> H. L. Smith	X	X(M)
<u>Stauroneis</u> sp.		X
<u>Stephanodiscus hantzschii</u> Grun.		
<u>Stephanodiscus</u> sp.		X
<u>Synedra delicatissima</u> W. Smith		X
<u>Synedra rumpens</u> Kutz.	X	X
<u>Synedra planktonica</u> Hains and Sebring	X	X(M)
<u>Synedra ulna</u> (Nitz.) Ehr.	X	X
<u>Synedra vaucheriae</u> Kutz.		X
<u>Tabellaria fenestrata</u> (Lynbg.) Kutz.	X	X(M)
Chlorophyta		
<u>Actinastrum hantzschii</u> Lag.		X
<u>Ankistrodesmus convolutus</u> Corda		X
<u>Ankistrodesmus falcatus</u> (Corda) Ralfs	X	X(M)
<u>Ankistrodesmus falcatus</u> v. <u>mirabilis</u> (Corda) Ralfs		X(M)
<u>Ankistrodesmus spiralis</u> (Turner) Lemm.		X(M)
<u>Arthrodesmus</u> sp.		X
<u>Botryococcus braunii</u> Kuetzing		
<u>Carteria</u> sp.	X	X
<u>Chlamydomonas</u> sp.	X(M)	X(M)

Table L-7. Phytoplankton collected from Pond C and Par Pond
(continued)

Species	Pond C	Par Pond
Chlorophyta (continued)		
<u>Chlorogonium elongatum</u> (Dang.) Franze	X(M)	
<u>Chlorogonium euchlorum</u> Ehr.	X(M)	
<u>Closteridium lunula</u> Nitzsch.	X	
<u>Closteridium</u> sp.		
<u>Closteriopsis longissima</u> Lemm.		X
<u>Coelastrum cambricum</u> Archer	X	X
<u>Coelastrum proboscideum</u> Bohlin	X	X
<u>Cosmarium</u> sp. 1		X
<u>Cosmarium tenue</u> Archer		
<u>Crucigenia quadrada</u> Morren		X
<u>Crucigenia tetrapedia</u> (Kirch.) West and West		X
<u>Dictyosphaerium pulchellum</u> Wood		X
<u>Elakatothrix gelatinosa</u> Wille		X
<u>Elakatothrix viridis</u> (Snow) Printz		
<u>Eudorina elegans</u> Ehr.		X
<u>Franceia droescheri</u> (Lemm.) G. M. Smith	X	X
<u>Franceia ovalis</u> (France) Lemm.		X
<u>Gloeocystis ampla</u> (Kutz.) Lag.		X
<u>Gloeocystis gigas</u> (Kutz.) Lag.		X
<u>Gloeocystis planctonica</u> (West and West) Lemm.	X	X
<u>Gloeocystis vesiculosa</u> Naeg.		X
<u>Gloeocystis</u> sp.		X
<u>Golenkinia radiata</u> (Chod.) Wille	X	X(M)
<u>Gonatozygon aculeatum</u> Hastings		
<u>Gonatozygon brebissonii</u> De Bary		X
<u>Gonium pectorale</u> Mueller	X	X
<u>Kirchneriella contorta</u> (Schmidle) Bohlin		
<u>Kirchneriella lunaris</u> (Kirch.) Moebius		
<u>Kirchneriella subsolitaria</u> G. S. West	X	X
<u>Lagerheimia quadriseta</u> (Lemm.) G. M. Smith		X
<u>Lagerheimia</u> sp.		
<u>Micractinium pusillum</u> Fresenius	X(M)	X
<u>Mougeotia</u> sp.	X	X
<u>Nephrocytium</u> sp.	X	
<u>Oedogonium</u> sp.	X	
<u>Oocystis borgei</u> Snow		X
<u>Oocystis elliptica</u> W. West		X
<u>Oocystis gloecystiformis</u> Borge		
<u>Oocystis lacustris</u> Chod		X
<u>Oocystis parva</u> West and West		
<u>Oocystis pusilla</u> Hansgirg	X	X
<u>Pandorina charkowiensis</u> Korshikov	X	
<u>Pandorina morum</u> (Muell) Bory	X	

Table L-7. Phytoplankton collected from Pond C and Par Pond
(continued)

Species	Pond C	Par Pond
Chlorophyta (continued)		
<u>Pediastrum boryanum</u> (Turp) Meneghini		X
<u>Pediastrum duplex</u> Meyen	X	
<u>Pleurotaenium</u> sp.		
<u>Plurotaenium tridentulum</u> (Wolle) West		X
<u>Protococcus viridis</u> C. A. Agardh		
<u>Scenedesmus abundans</u> (Kirch.) Chod.	X	
<u>Scenedesmus bijuga</u> (Turp.) Lag.	X	
<u>Scenedesmus brevispina</u> (Smith) Chod.	X	X
<u>Scenedesmus denticulatus</u> Lag.	X	X
<u>Scenedesmus intermedius</u> Chod.		X
<u>Scenedesmus longispina</u> v. <u>asymmetricus</u> Hortob.	X	
<u>Scenedesmus opoliensis</u> P. Richter	X	X
<u>Scenedesmus quadricausa</u> (Turp) Breb.	X	X
<u>Schroederia setigera</u> (Schroed.) Lemm.	X	X
<u>Selenastrum capricornutum</u> Printz.		X
<u>Selenastrum gracile</u> Reinsch		X
<u>Selenastrum minutum</u> (Naeg.) Collins	X(M)	X(M)
<u>Staurastrum brasiliense</u> W. and G. S. West		
<u>Staurastrum chaetoceros</u> (Schroed.) G. M. Smith		X
<u>Staurastrum paradoxum</u> Meyen		X
<u>Staurastrum ravenellii</u> Irene-Marie		X
<u>Staurastrum</u> sp. 1	X	X
<u>Staurastrum</u> sp. 2		
<u>Tetraedron caudatum</u> (Corda) Hansgirg	X	X
<u>Tetraedron gracile</u> (Reinsch) Hansgirg	X	
<u>Tetraedron minimum</u> (A. Braun) Hansgirg		X
<u>Tetraedron regulare</u> Kutz.		X
<u>Tetraedron</u> sp.		X
<u>Tetraedron trigonum</u> (Naeg.) Hansgirg		X
<u>Tetrastrum staurogeniaeforme</u> (Schroed.) Lemm		X
Undetermined green flagellates		X(M)
<u>Westella botryoides</u> (W. West) deWildemann		X
<u>Xanthidium cristatum</u> v. <u>leioderium</u> W. and G. S. West		
<u>Xanthidium</u> sp.		X
Cyanophyta		
<u>Anabaena</u> sp.	X	X(M)
<u>Anacystis</u> sp.	X	X(M)
<u>Arthrospira jenneri</u> (Kutz) Stitz.		
<u>Arthrospira</u> sp.	X	
<u>Chroococcus limneticus</u> Lemm.		
<u>Chroococcus</u> sp.	X	X
<u>Dactylococcopsis fascicularis</u> Lemm.	X	

Table L-7. Phytoplankton collected from Pond C and Par Pond
(continued)

Species	Pond C	Par Pond
Cyanophyta (continued)		
<u>Lyngbya limnetica</u> Lemm.	X(M)	X(M)
<u>Mastigocladus laminosus</u> Cohn.	X(M)	X
<u>Merismopedia</u> sp.	X	
<u>Merismopedia tenuissima</u> Lemm.	X	X
<u>Merismopedia trolleri</u> Bachmann		
<u>Oscillatoria geminata</u> Menegh	X	X
<u>Oscillatoria princeps</u> Vaucher	X	
<u>Oscillatoria</u> sp.	X	
<u>Phormidium</u> sp.	X(M)	X
<u>Schizothrix</u> sp.		X
<u>Spirulina major</u> Kutz.		X
Cryptophyta		
<u>Chroomonas</u> sp.	X	
<u>Cryptomonas erosa</u> Ehr.	X	X(M)
<u>Cryptomonas marsonii</u> Skuja		X
<u>Rhodomonas minuta</u> Skuja	X(M)	X(M)
<u>Rhodomonas</u> sp.	X	X(M)
Chrysophyta		
<u>Chromulina</u> sp.	X(M)	
<u>Dinobyron divergens</u> Imhof.	X(M)	X
<u>Dinobyron sertularia</u> Ehr.		
<u>Mallomonas alpina</u> Pascher and Ruttner		
<u>Mallomonas caudata</u> Conrad		X
<u>Mallomonas pseudocoronata</u> Prescott		X
<u>Mallomonas</u> sp.		X
<u>Mallomonas tonsurata</u> Teiling		X
<u>Ochromonas</u> sp.		X
<u>Ophiocytium capitatum</u> Wolle		
<u>Ophiocytium capitatum</u> v. <u>longispinum</u> (Moebius) Lemm.		X
<u>Synura caroliniana</u> Whitford		
<u>Synura petersenii</u> Korshikov		X
<u>Synura uvella</u> Ehr.		X
Pyrrhophyta		
<u>Glenodinium</u> sp.		X
<u>Peridinium</u> sp.	X	X

Table L-7. Phytoplankton collected from Pond C and Par Pond
(continued)

Species	Pond C	Par Pond
Euglenophyta		
<u>Euglena minuta</u> Prescott		X
<u>Euglena</u> sp. 1		
<u>Euglena</u> sp. 2	X	X
<u>Eutreptia viridis</u> Perty	X	
<u>Lepocinclis</u> sp.		
<u>Phacus</u> sp.	X	
<u>Trachelomonas horrida</u> Palmer		X
<u>Trachelomonas</u> sp.	X	
<u>Trachelomonas volvocina</u> Ehr.	X	
Rhodophyta		
<u>Audouinella violacea</u> (Kuetz.) Hamel	X	

^aTaken from Wilde (1983).

^bX = observed in a least one sample from the reservoir.

CM = major taxon comprising more than 5 percent of the total
phytoplankton in at least one sample.

Table L-8. Periphyton collected from the Par Pond System

Principal taxa in the P-Reactor canal above Par Pond (taken from Tison et al., 1981).

Mastigocladus laminosus
Phormidium sp.
Oscillatoria sp.
Oedogonium sp. 1
Oedogonium sp. 2
Navicula confervacea
Melosira granulata
Synedra delicatissima

Principal diatoms in Par Pond (from artificial substrate sampling) unpublished data.^a

Achnanthes affinis
Achnanthes lanceolata
Achnanthes minutissima
Anomoeoneis vitrea
Cyclotella pseudostelligera
Cyclotella stelligera
Cymbella delicatula
Cymbella microcephala
Cymbella minuta v. silesiaca
Fragilaria crotonensis
Fragilaria pinnata
Fragilaria vaucheriae
Gomphonema carolinense
Gomphonema grunowii
Gomphonema intricatum
Gomphonema parvulum
Gomphonema sudcavatum
Melosira distans v. alpigena
Melosira granulata v. angustissima
Nitzschia frustulum
Nitzschia frustulum v. perminuta
Synedra delicatissima v. angustissima
Synedra minuscula
Synedra rumpens
Synedra tenera
Synedra ulna
Tabellaria fenestrata

Nondiatomic algae from artificial substrate sampling (unpublished data^a).

Actinastrum hantschii
Agmenellum elegans
Amphidinium sp.

Table L-8. Periphyton collected from the Par Pond System
(continued)

Nondiatomc algae from artificial substrate sampling (unpublished data^a).
(continued)

Anabaena circinalis
Anabaena sp.
Anacystis cyanea
Ankistrodemus falcatus
Arthrodesmus octocornis
Bulbochaete sp.
Calothrix sp.
Ceratium hirundinella
Chlamydomonas sp.
Closterium cornu
Closterium sp.
Closterium venus
Cosmarium angulosum
Cosmarium asphaerosparum
Cosmarium bireme
Cosmarium bisphaericum
Cosmarium blyttii
Cosmarium circulare
Cosmarium comminurale v. crassum
Cosmarium dentatum
Cosmarium excavatum f. diplomajor
Cosmarium exiguum
Cosmarium goleritum
Cosmarium impressulum
Cosmarium margaritatum
Cosmarium pardalis
Cosmarium phaseolus
Cosmarium pseudoconnatum
Cosmarium schliephakeanum
Cosmarium spp.
Cosmarium subcrenatum
Cosmarium tenue
Cosmocladium saxonicum
Dictyosphaerium pulchellum
Euastrum ciastonii
Euastrum denticulatum
Gleocapsa sp.
Gonatozygon aculeatum
Gonatozygon brebissonii
Gonatozygon monotaenium
Microcoleus iriguus
Microcoleus sp.
Microcoleus vaginatus
Mougeotia sp.
Nostoc macorum

Table L-8. Periphyton collected from the Par Pond System
(continued)

Nondiatomc algae from artificial substrate sampling (unpublished data^a).
(continued)

Nostoc sp.

Oedogonium sp.

Oocystis borgei

Oscillatoria lutea

Oscillatoria princeps

^aIdentifications made by the Academy of Natural Sciences of Philadelphia
under subcontract with Du Pont.

Table L-9. Zooplankton collected from the Par Pond system

CLADOCERA

BOSMINIDAE

Bosmina longirostris
B. longirostris cornuta
Eubosmina hagmanni
E. tubicens

CHYDORIDAE

Acroperus of. harpae
Alona affinis
A. globulosa
A. guttata tuberculata
A. intermedia
A. karua
A. rectangula
A. rustica
A. setulosa
A. verrucosa
A. sp.
Alonella hamulata
Chydorus brevilabris
C. piger
(C. sphaericus)
Camptocercus cf. rectoripstris
Disparalona acutirostris
(Eurycercus lamellatus)
Eurycercus (Bullatifrons) sp.
E. (Eurycercus) microdontus
Pleuroxus denticulatus
Pseudochydorus globosus

DAPHNIIDAE

Ceriodaphnia lacustris
C. quadrangula
C. sp.
Daphnia parvula
Scapholebris kingi
Simocephalus serrulatus
S. vetulus

HOLOPEDIDAE

(Holopedium amazonicum)
Holopedium cf. gibberum

Table L-9. Zooplankton collected from the Par Pond system
(continued)

MACROTHRICIDAE

Ilyocryptus spinifer
Macrothrix laticornus
Macrothrix rosea

MOINIDAE

Moina micrura
M. sp.

COPEPODS

Cyclops leucarti
Cyclops spp.
Diaptomus spp.
Unidentified calanoids

ROTIFERS

Ascomorpha
Asplanchna
Canochilus
Kellicottia
Keratella
Polyarthra
Ptygura
Trichocera

INSECTA (Diptera)

Chaoborus punctipennis

OSTRACODA

Physocypria pustulosa Sharpe
Cypretta uiridis Thompson
Cypridopsis vidua O. F. Muller
Stenocypris fontinalis Varura
Strandesia spinulosa Bronstein
Metacypris americana Furtos
Darwinula stevenson Brady and Robertson

Table L-10. Predicted plankton scenarios for 1000-acre lake

Temp. (°C)	Expected Condition of Plankton Community
30-32.2	High primary production, some thermal stress causing decreased diversity and species composition altered from ambient condition
32.2-35	Blue-green algae replacing diatoms and flagellates; dominance of "summer" type zooplankton in all seasons
35-40	Blue-greens dominant, copepods principal zooplanktons, sporadic algal blooms with accompanying dissolved-oxygen depletion likely
40-45	Zooplankton virtually eliminated
45-50	Total domination of phytoplankton by bluegreens likely
50-55	Phytoplankton limited to only 1-3 species
55-60	Possible monoculture of thermophilic blue-green algae
>60	No primary production

Table L-11. Dominant aquatic macrophytes in Par Pond and Pond C

Species	Par Pond	Pond C
Submerged:		
<u>Myriophyllum spicatum</u> Eurasian watermilfoil	A	-
<u>Potamogeton diversifolius</u> Pondweed	A	-
<u>Najas guadalupensis</u> Bushy pondweed	A	-
<u>Ceratophyllum demersum</u> Coontail	O	-
<u>Utricularia inflata</u> Bladderwort	O	-
Floating-leafed:		
<u>Nelumbo lutea</u> - Lotus	A	-
<u>Nympha odorata</u> - Water lily	A	-
<u>Brasenia schreiberi</u> Water shield	A	-
<u>Numphoides cordata</u>	O	-
Emergent:		
<u>Eleocharis acicularis</u> Tiny spikerush	A	O
<u>Elocharis equisetoides</u> Spikerush	A	-
<u>Eleocharis quadrangulata</u> Spikerush	A	-
<u>Typha latifolia</u> Common cattail	A	-a
<u>Typha domingensis</u> Giant cattail	A	-

Table L-11. Dominant aquatic macrophytes in Par Pond and Pond C
(continued)

Species	Par Pond	Pond C
Emergent: (continued)		
<u>Scirpus cyperinus</u> - Bullrush	A	- ^a
<u>Erianthus giganteus</u> Giant plume grass	0	-
<u>Bacopa caroliniana</u>	A	-
<u>Pontaderia cordata</u> - Pickerelweed	0	-
<u>Mayaca aubletti</u> - Bog moss	0	-
<u>Ludwigia leptocarpa</u> Water primrose	0	0 ^b
<u>Ammannia coccinea</u>	0	0 ^b
<u>Rotala ramosa</u>	0	0 ^b
<u>Hydrocotyle umbellata</u> Pennywort	A	-

A - Abundant

0 - Occasional or infrequent

^aDoes not typically occur along the shoreline. May occasionally grow in cool refuge coves.

^bInfrequent on the shoreline; not actually growing in the water.

Only three plants are present in Pond C, and these live above the normal water level. However, 23 species are reported from Par Pond: 5 submerged forms, 4 floating-leafed, and 14 emergent. The standing crop of submerged macrophytes in heated areas of Par Pond was twice that of the unheated area (Grace and Tilly, 1976). This type of plant development in the 1000-acre lake would be sufficient to support a balanced fish community.

The aquatic communities in the reach of Steel Creek above the lake would probably be very similar to those present previously when L-Reactor was operational and the thermal effluent below the outfall isolated this area from downstream influences.

L.4.1.1.3 Socioeconomic impacts

The socioeconomic impacts of operation would be almost the same with the 1000-acre lake as with the direct discharge alternative (reference case). Operational employment for L-Reactor, which began in 1981, peaked at about 400 employees in mid-1983 and is expected to decrease to 350 by mid-1984, or about 4 percent of the current work force at the Savannah River Plant (Du Pont, 1982b). Essentially all the operating work force for L-Reactor has been hired and resides in the SRP area; therefore, no additional impacts due to in-migrating workers are expected to local communities and services. Operating, maintenance, and general service requirements would be performed by personnel sharing duties with normal L-Reactor requirements.

L-Reactor operation is expected to have annual total local expenditures on materials and services of approximately \$3 million and a total payroll and overhead expenditure of about \$21 million. These expenditures are expected to result in the creation of about 50 regional job opportunities. In addition, these expected expenditures are anticipated to produce an additional direct and indirect income of another \$3 million. The total economic benefit to the SRP region during L-Reactor operation will amount to at least 400 direct and indirect job opportunities, about \$25 million in direct and indirect annual income and payroll, and \$3 million in direct annual expenditures on materials and services.

These contributions to the local economy will help pay for public services directly through income, property, and license taxes and user fees and help indirectly through sales taxes on goods and services. The benefits provided by the project will help offset the small increase in demands that it generates for local services.

L.4.1.2 Radiological impacts

L.4.1.2.1 L-Reactor radiological releases

The operation of L-Reactor with the preferred cooling-water alternative would have the same radiological releases and associated impacts as those described in Section 4.1.2, except power levels would be reduced to meet the criterion of about 50 percent of the lake being maintained below 32.2°C. The

power reduction would be approximately 14 percent; if precoolers are installed, the reduction would be approximately 3 percent.

L.4.1.2.2 Cesium-137/cobalt-60 remobilization

The resumption of L-Reactor operation would add only small amounts of radionuclides to Steel Creek. However, the reactivation would transport a portion of the cesium-137 and cobalt-60 inventories that remain in the Steel Creek channel and floodplain.

The transport of radioactivity associated with sediments from the 1000-acre lake would be smaller than that related to direct discharge to Steel Creek. This reduction would be due primarily to the low water velocities over the bottom of the lake and the near-zero erosion of contaminated sediments on the bottom of the lake. However, discharge water from the lake, which would be relatively sediment-free, could rapidly reach equilibrium sediment loading downstream from the embankment. Thus, the total transport of radioactivity by suspended sediments in the Steel Creek system might not differ much from that estimated for direct discharge (i.e., 2.3 curies in the first and second years).

The effects of a thermal lake on desorptive transport (i.e., solution transport) compared to the effects of a flowing stream are somewhat uncertain. However, they are expected to be no greater than those with a flowing stream. The area of contaminated soil exposed to water from a lake covering the contaminated floodplain sediment would be nearly the same as that if the L-Reactor cooling stream is discharged directly to the creek. The hot water would desorb the cesium-137 from the surface sediments on the bottom of the lake; however, the rate of desorption is expected to be significantly slower, because sediments would not be mixed with the water as vigorously as compared to a flowing stream, and the average temperature of water at the bottom of the lake would be considerably lower than the average temperature to which sediments are exposed during direct discharge. As cesium-137 concentration on the surface of the lake bottom sediments reduced from transport out of the lake, further loss would be smaller because diffusion is an extremely slow process for the transfer of material through the sediments.

It is known that in Par Pond, cesium deposits on the bottom of the pond become more soluble during anaerobic conditions (bottom water concentrations are about twice the surface concentrations) when there is thermal stratification in the spring and summer, and then cesium is mixed throughout the depth of the pond when water turnover occurs in the fall. Thermal stratification in the 1000-acre lake would enhance desorption somewhat; however, the net consequence of reduced temperature, reduced flow rate, and the anaerobic effect would be to lessen the transport.

Because the factors that could influence activity transport in the combined lake-stream system are difficult to quantify precisely, transport with the lake-stream system is conservatively estimated to be no more than that associated with direct discharge of cooling water to Steel Creek (i.e., 4.4 ± 2.2 curies of cesium-137 and 0.25 curie of cobalt-60 would be transported in the first year). In the second year, it is anticipated that this value would be reduced to $2.3 \pm$

1.8 curies. Thereafter, a 20-percent reduction in transport per year is assumed.

L.4.2 Accidents

L.4.2.1 Reactor accidents

Possible accidents and their consequences for the preferred cooling-water alternative are not expected to be different from those described in Section 4.2. Section 4.2.1 discusses reactor malfunctions and Section 4.2.2 discusses hazards due to natural phenomena and non-nuclear hazards. Appendix G treats reactor accidents in detail.

L.4.2.2 Embankment failure

The probability of an embankment failure is extremely low. As indicated in Section L.2.3.2, applicable seismic design criteria would be used for embankment construction. Similarly, the embankment and outlet works and the emergency spillway have been designed to control the runoff (Section L.2.3.1) from the U.S. Army Corps of Engineers' "standard project flood." At SRP this flood is the result of a 96-hour rainfall of 51 centimeters. The standard project flood does not have a direct correspondence to a recurrence interval. However, 51 centimeters in 96 hours is nearly twice the 100-year recurrence interval depth for the area. Extrapolation of the depth-versus-recurrence-interval relationship for the 96-hour duration at the site would imply a recurrence interval of over 10,000 years. An even rarer flood, the probable maximum flood, was also included in the design basis. The embankment is designed to withstand these events.

The consequence analyses of embankment failure indicate that any loss of life is unlikely because no SRP facilities or offsite residences exist in the expected path of the resulting flood wave. However, severe economic loss and environmental impacts would occur.

The consequence analyses of embankment failure were based on a reservoir water-surface elevation of 61 meters. This is the elevation at the top of the embankment, 1.2 meters above the emergency spillway and 1.6 meters above the peak pool level for the standard project flood. Results of the analyses indicate that a failure with the water at the 61-meter elevation would produce a 14-meter-high flood wave. The wave height would decrease as it proceeded downstream. At a distance of 3.7 kilometers downstream from the embankment, the wave height would be about half the initial height, or 7 meters. This station is below the Seaboard Coast Line Railroad bridge and the bridge over Road A (SC Highway 125). These bridges would be overtopped and probably destroyed, and their debris would be carried by the flood wave.

At a distance of 5.2 kilometers downstream from the embankment, the wave would have a height of approximately 3.5 meters and be fully into the Savannah River swamp, both on and off the site. This is downstream from the second Seaboard Coast Line Railroad bridge which is about 900 meters above Cypress

Bridge. This railroad bridge would probably be destroyed or severely damaged. The swamp is not deep enough to sustain a wave height of 3.5 meters, and the trees and shrubs would also attenuate the wave. However, as the wave breaks and scatters through the swamp, it would uproot trees and vegetation and then deposit the entrained debris, including earth from the embankment, scoured sediment, and bridge debris. The effect on the Savannah River itself is expected to be minor.

L.5 MONITORING

L.5.1 Water-quality monitoring

NPDES permit conditions are not finalized. The following is an outline of the anticipated program of measurements designed to assure a balanced biological community in the 1000-acre cooling lake during the initial period of L-Reactor operation.

L.5.1.1 L-Reactor effluent monitoring

The L-Reactor outfall parameters would be monitored as required by the NPDES permit.

L.5.1.2 Lake monitoring

The temperature of the lake would be surveyed on a regular basis with sufficient monitoring points to validate the thermal predictions concerning the lake and also to demonstrate a balanced biological community in the lake and other NPDES requirements.

During the first 3 to 5 years of L-Reactor operation, the Section 316(a) studies would be reported to the State annually or in accordance with the requirements of the NPDES permit.

L.5.2 Embankment inspection and monitoring

Inspection of the embankment would be conducted on a regular basis. Three levels of inspection are planned: a monthly inspection of the embankment; a biannual inspection of all outlet works, gates, and spillways; and an annual settlement check. All inspections would follow standard procedures similar to those established for Par Pond.

The monthly inspection of the embankment would include but not be limited to the following:

1. Measurement of water levels in piezometers.

2. Observation of the embankment slopes for surface cracks, evidence of seepage on the surface, evidence of piping or boils, and condition of the protective covering.
3. Observation of the abutments for evidence of piping or boils or other evidence of seepage.
4. Observation of toe, the embankment, and downstream areas for surface cracks, heaving, and increased seepage.

A biannual inspection would be performed on all outlet works, gates, and the spillway area. The purpose of this inspection would be to determine the condition of the physical, mechanical, and electrical facilities and equipment associated with the various appurtenances with the embankment.

On an annual basis, surveying and leveling of settlement pins located on and around the embankment would be made to determine if there was any indication of excessive settlement or movement.

The results of all inspections would be formally documented and the data stored at SRP for easy access and comparison for further readings or observations.

L.5.3 Radiological monitoring

The radiological monitoring program would include the monitoring of air on and off the site, water from SRP streams and the Savannah River, the SRP ground water, and samples of soil, vegetation, food, drinking water, animals, and fish for their radionuclide content. In addition, aerial radiological surveys of the Savannah River Plant and surrounding areas are conducted periodically by the DOE Remote Sensing Laboratory, operated by EG&G. Independent radiological monitoring programs are also conducted by the South Carolina Department of Health and Environmental Control (SCDHEC) and the Georgia Department of Natural Resources (GDNR).

This program would be the same as that for the reference case (described in Section 6.1), except sampling in Steel Creek will include the lake water and lake sediments.

L.5.4 Radiocesium remobilization monitoring

DOE has established a comprehensive environmental monitoring program to determine the transport of cesium-137 from the Savannah River Plant resulting from the startup of L-Reactor. The program consists of analyses of water samples from Steel Creek, the Savannah River, and the downstream water supplies (Beaufort-Jasper, South Carolina, and Port Wentworth, Georgia). Cesium-137 is not detectable in upstream or downstream river samples by routine monitoring techniques that have minimum detection limits of about 1.0 picocurie per liter. The routine monitoring program has been in effect at the site for about 30

years. A special monitoring for cesium-137 and total suspended solids would be conducted for a minimum of 1 year following L-Reactor startup and operation.

Aerial radiological surveys of the Savannah River Plant and surrounding areas were conducted by the DOE Remote Sensing Laboratory, operated by EG&G, Las Vegas, in 1974, 1979, 1982, and 1983. These surveys would continue after L-Reactor startup.

Special monitoring programs for cesium-137 and total suspended solids were conducted during cooling-water cold-flow tests. These data were used to evaluate releases from individual tests and to verify transport models used to estimate the remobilization of cesium during reactor operations. During tests of limited flow, weekly composite water samples were taken at the mouth of Steel Creek and at Cypress Bridge. For the full-flow tests, daily composite water samples would be taken at multiple points along Steel Creek. Additional special sampling would be made to determine the amount of cesium-137 transported in the suspended sediments.

The drinking-water monitoring program would include measurements of both cesium-137 concentration in the Savannah River above and below the Savannah River Plant and water-treatment plant raw and finished water above and below the Plant. The Savannah River estuary and the Savannah River, as well as water-treatment sludge ponds, would be studied to determine potential cesium-137 buildup in sediments. These measurements started in March 1983, and will continue for at least 1 year following L-Reactor startup.

Measurements in the Savannah River would provide a material balance of the total cesium-137 discharged to and transported by the river. Measurements of raw river water and finished drinking water would provide cesium-137 concentrations to verify earlier estimates made for transport. Measurements of cesium-137 in the estuary would be compared to earlier measurements to determine long-term trends.

L.5.5 Ecological monitoring

The principal objective of the aquatic biological monitoring program that will be established will be to demonstrate that there is, in the cooling lake, a balanced community of aquatic organisms. The program will be designed to characterize the development and stabilization of the ecological communities that will evolve in the new impoundment. Information generated by the studies will also be used for preparing a predictive Section 316(a) demonstration for the cooling-lake system.

As with any newly filled reservoir, the ecological system in the cooling lake would require at least 3 to 5 years to reach maturity and stabilize. In the process, it would pass through a series of characteristic developmental stages that have been observed and documented at other new reservoirs. A balanced biological community of aquatic organisms would not be established until the lake reached maturity. Accordingly, the ecological program would have two phases: (1) monitoring the natural communities through the developmental period (from 3 to 5 years) and establishing when a state of balance has been

achieved, and (2) monitoring the balanced community (for a period of time to be determined later) after stability is achieved to ensure that it does not degrade over the longer term. The second phase would require a lower level of effort than the first and would focus on carefully selected organisms to be chosen as indicators of the communities that eventually develop in the cooling lake. As described in Section L.4.1.1.2, it is not possible a priori to describe the nature and complexity of the aquatic community that will become established, nor is it possible to predict which species will be dominant or important or which will serve as good indicators of the balance within the community. Accordingly, the second phase of the biological monitoring program cannot be planned in detail until after the lake has reached maturity and the aquatic communities attain a balanced state. This should occur from 3 to 5 years after the lake is filled. At that time DOE, in consultation with SCDHEC officials, would design and institute a revised monitoring program.

The first phase of the ecological monitoring program would begin as soon as the 1000-acre lake was constructed. It would be similar in design and execution to the program now underway at Par Pond; this program is summarized in Table L-12. Sampling gear types and collection techniques would be the same both to maximize the comparison of data obtained from the two lakes and to take maximum advantage of the experience being gained by the ongoing Par Pond investigations. The frequency of sampling would be similar--monthly or quarterly, depending on the parameter under study.

<u>Parameter</u>	<u>Sampling frequency</u>
Phytoplankton	Monthly
Zooplankton	Monthly
Meroplankton	Monthly
Macroinvertebrates	Quarterly
Macrophytes/habitat formers	Quarterly
Fish	Monthly
Water chemistry	Monthly

Sampling locations would be established at strategic points within the lake and in areas downstream and upstream of the lake. Based on experience with other ongoing studies at SRP, approximately 10 to 15 stations would be set up in the lake, as would some 4 to 6 stations in both the upstream and downstream reaches. The locations of these stations cannot be selected until detailed predictions of the isothermal patterns within the lake are completed prior to its being filled.

L.5.6 Archeological sites

Data recovery of sites impacted by the lake would be completed prior to flooding. During construction, historic, archeological, and cultural resources in the contractor's work area would be designated; precautions would be taken to preserve all such resources. The contractor would install protection for these resources and would be responsible for their preservation. If, during construction activities, the contractor observed unusual items that might have historic

Table L-12. Summary of ongoing aquatic studies at Par Pond

Parameter	Number of Stations	Principal Gear Types
Phytoplankton	6 stations x 4 depths	Van Dorn water bottle
Zooplankton	6 stations x 4 depths	Filter water through 76 micron or 35 micron netting
Meroplankton	7 stations x 2 depths	0.5 m towed nets with 505 micron mesh
Macroinvertebrates	6 stations x 3 sublocations	Petit Ponar bottom grab sampler
Fish	6 stations	Electrofishing, hoop nets, gill nets, angling
Water Chemistry	6 stations	<u>In situ</u> meter and water samples
Temperature ^a		
Dissolved oxygen ^a		
pH ^a		
Conductivity ^a		
Primary productivity		
Alkalinity		
Total organic carbon		
Total carbon		
Total inorganic carbon		
Chlorophyll-a		
Nitrate/nitrite		
Ammonia		
Silica		
Ortho-phosphate		
Total phosphate		
Potassium		
Magnesium		
Manganese		
Iron		
Calcium		
Cobalt		
Chloride		

^aMeasured by in situ metering.

or archeological value, he would take precautions to preserve the items carefully; such observations would be reported as soon as practicable.

During the first 2 years of L-Reactor operation, those sites not expected to be affected but near Steel Creek below the embankment would be monitored on a monthly basis to determine whether erosion had occurred. If no erosion was evident at the end of the 2-year monitoring period, then the sites should be considered sufficiently protected to assure preservation.

Active erosion protection would be undertaken in the event that adverse erosion threatened the integrity of any of the sites. If erosion barriers were ineffective, recovery and documentation of the archeological data would be carried out.

L.6 FEDERAL AND STATE ENVIRONMENTAL REQUIREMENTS

This section summarizes the Federal and State of South Carolina requirements that are applicable to the resumption of L-Reactor operation, based on the construction and operation of the preferred cooling-water alternative with a 1000-acre lake. Chapter 7 contains general synopses of the applicable laws and regulations. This alternative would require a number of permits or processes regarding water quality, floodplain/wetlands, historic preservation, endangered species, air quality, and noise. The specific requirements for each are described in the following sections:

L.6.1 Surface-water quality

Permits and processes associated with water quality include (1) an NPDES permit, (2) a predictive Section 316(a) demonstration, (3) a U.S. Army Corps of Engineers 404 permit, and (4) an SCDHEC 401 certification.

Section 402 of the Clean Water Act, as amended, is the basis for controlling "point source" discharges of pollutants into navigable waters of the United States through the National Pollutant Discharge Elimination System (NPDES); this system is administered by the EPA, which has delegated NPDES permitting authority in South Carolina to the State of South Carolina. DOE applied to the State in 1981 for renewal and consolidation of its original NPDES permits. All L-Area outfalls with the potential for future use were included in the NPDES permit renewal application. Between 1981 and 1983, negotiations between SCDHEC and DOE were held to resolve issues related to the L-Reactor NPDES permit.

On December 15, 1983, SCDHEC announced its determination to issue a renewal NPDES permit to DOE for the Savannah River Plant, to be effective January 1, 1984. Based on this permit and a mutually agreed on consent order, all discharges except the thermal discharge from L-Reactor would be permitted. Thermal

discharges from the three operating SRP reactors (C, K, and P) would be permitted, provided DOE would:

1. Complete a comprehensive study of the thermal effects of all operations at the Savannah River Plant
2. Complete and submit thermal mitigation studies to SCDHEC within 9 months of signing of the consent order
3. Implement the recommended thermal mitigation alternative approved by SCDHEC under a schedule to be established by SCDHEC in a subsequent order
4. Submit and actively support appropriate funding requests to accomplish any actions resulting from the thermal studies.

All L-Area non-reactor cooling-water effluent discharges are permitted pursuant to the December 15, 1983, announcement, including the discharge of sanitary wastewater and various nonprocess cooling waters from the control building, pumphouse, offices, and security building.

SCDHEC considers the proposed 1000-acre lake to be Class B waters of the State. This interpretation would limit the temperature of thermal effluents from L-Reactor as follows [SCDHEC, 1981; Section C.(7)].

- Discharge to a lake or reservoir - The temperature of the discharge "shall not exceed a weekly average temperature of 90°F (32.2°C) after adequate mixing as a result of heated liquids, nor shall a weekly average temperature rise of more than 5°F (2.8°C) above temperatures existing under natural conditions be allowed as a result of the discharge of heated liquids unless an appropriate temperature criteria or mixing zone, as provided below, has been established. The water temperature at the inside boundary of the mixing zone shall not be more than 18°F (10°C) greater than that of water unaffected by the heated discharge. The appropriate temperature criteria or the size of the mixing zone shall be determined on an individual project basis and shall be based on biological, chemical, engineering and physical considerations. Any such determination shall assure the protection and propagation of a balanced, indigenous population of shellfish, fish and wildlife in and on a body of water to which the heated discharge is made and shall allow passage of aquatic organisms."
- Case-by-case determinations - "Upon a case-by-case determination by the Department and in accordance with the Act, the Clean Water Act (P.L. 92-500, 95-217), and related regulations, the above temperature criteria may not apply to cooling water bodies with a primary purpose of providing a source and/or being a receptor of industrial cooling water."

As noted in Section C(8) of the Water Quality Standards (SCDHEC, 1981), the temperature standards for Class B waters of the State are applicable when the flow rate is equal to or greater than the minimum 7-day average flow rate that

occurs with an average frequency of once in 10 years. However, the temperature of the discharge cannot be so high that it interferes with water uses or is harmful to human, animal, plant, or aquatic life.

The preferred alternative (the 1000-acre cooling lake) is designed to meet these requirements; it is the subject of ongoing discussions with SCDHEC. The objective of these discussions is the incorporation of L-Reactor thermal discharges into the overall SRP NPDES permit.

In early December 1983, DOE also initiated discussions with the U.S. Army Corps of Engineers on dredge and fill permits under Sections 9 and 10 of the River and Harbor Act and Section 404 of the Clean Water Act. To allow a possible expedited schedule, DOE has submitted its 404 application for the 1000-acre lake, and the public notice describing the proposed construction has been issued.

The public notice of the 404 application also includes a paragraph that constitutes a request by the Corps of Engineers for a review in accordance with Section 401 of the Clean Water Act. Section 401 requires certification from the State (i.e., SCDHEC) that construction and operation-related discharges into the navigable waters will comply with the applicable effluent limitations and water-quality standards of the Clean Water Act. This certification is a prerequisite for the 404 permit approval from the U.S. Army Corps of Engineers.

L.6.2 Floodplain/wetlands

DOE issued a floodplain/wetlands notice regarding the proposed reactivation of L-Reactor on July 14, 1982 (47 FR 30563). A floodplain/wetlands determination regarding no practical alternative was published in the Federal Register on August 23, 1982 (47 FR 36691-2). The floodplain/wetlands assessment has been updated (see Appendix I) and the floodplain/wetlands determination will be updated and/or modified after the completion of the Final Environmental Impact Statement.

The Fish and Wildlife Service's mitigation policy for wetlands is stated in 46 FR 7644-7663. This policy establishes four resource categories to establish mitigation levels consistent with the fish and wildlife resources involved. The wetlands that would be impacted by the restart of L-Reactor are categorized under Resource Category 2 as habitat of "high value for evaluation species" and are "scarce or becoming scarce." The mitigation goal under this policy requires that there be "no net loss of inkind habitat value."

The Department of Energy is working with the Department of Interior to perform a Habitat Evaluation Procedure (HEP). The HEP will identify the value of habitat to be gained or lost with the implementation of the preferred cooling-water mitigation alternative for use in assessing further mitigation. If required, DOE will implement additional mitigative measures that might be identified through the HEP process, depending on Congressional authorization and appropriation.

L.6.3 Historic preservation

The area subject to impact by this alternative contains one prehistoric site and four historic sites eligible for inclusion in the National Register. These sites would be subject to erosion and flooding due to the high water-flow conditions and the establishment of the impoundment. A resource recovery plan has been developed by the University of South Carolina Institute of Archeology and Anthropology and consultations with the SHPO and the Advisory Council on Historic Preservation (ACHP) have been completed. The mitigation plan has been approved by the SHPO and ACHP (Lee, 1982). Erosion and transport of sediment are expected to be slightly reduced in relation to direct discharge.

In March 1984, an intensive survey of the proposed excavation areas (embankment and borrow pit areas) was made (Brooks, 1984). This survey identified seven sites described as of ephemeral quality and not eligible for nomination to the National Register of Historic Places.

Archeological surveying and testing are presently being conducted in the proposed lake area by the University of South Carolina Institute of Archeology and Anthropology. It is anticipated that several sites associated with the Ashley Plantation will be affected. The schedule for completion of the requirements under the National Historic Preservation Act, including data recovery, is consistent with the construction schedule for the embankment, and all mitigation will be completed prior to restart (Hanson, 1984).

L.6.4 Endangered species

Pursuant to the requirements of the Endangered Species Act of 1973, DOE has engaged in a consultation process with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service for the species discussed below.

L.6.4.1 American alligator

Formal consultation on the American alligator was held under the Endangered Species Act in September 1982 with representatives of DOE-SR, Du Pont, NUS Corporation, the Savannah River Ecology Laboratory (SREL), and the U.S. Fish and Wildlife Service (FWS). A Biological Opinion received from the FWS judged that protection of the lagoons at SRP Road A should provide sufficient mitigation for the American alligator potentially affected by the L-Reactor restart under the direct discharge alternative. Protection of these lagoons has been completed. Because the preferred cooling-water alternative is now the 1000-acre lake, DOE has reinitiated consultations with FWS. DOE has transmitted the most recent information on impact projections for this species (Sires, 1984b) to the FWS. DOE is awaiting a decision on its conclusion that the impacts resulting from the delayed restart of L-Reactor will not jeopardize the continued existence of this species.

L.6.4.2 Red-cockaded woodpecker

The FWS has determined that the red-cockaded woodpecker will be unaffected by L-Area operations.

L.6.4.3 Shortnose sturgeon

Sturgeon larvae were identified in water samples taken near the SRP pump-houses at the Savannah River in 1982 and 1983. A few of these were determined to be the federally endangered shortnose sturgeon. A biological assessment and consultation process with the National Marine Fisheries Service (NMFS) has been completed for this species. NMFS has concurred with the DOE determination that the population of the shortnose sturgeon in the Savannah River would not be jeopardized (Oravetz, 1983).

L.6.4.4 Wood stork

The endangered wood stork forages at the Savannah River Plant, but does not breed on the site. The feeding individuals have been observed to be from the Birdsville Rookery, some 50 kilometers away. DOE initiated informal consultation with FWS in July 1983 and in March 1984. DOE has prepared a biological assessment for FWS review and use in formulating its Biological Opinion. DOE is continuing to conduct studies and apprise FWS of the results (Sires, 1984a).

L.6.5 Air quality

The authority for the regulation of air emissions has been delegated by the EPA to the Bureau of Air Quality Control of the SCDHEC. The Bureau issues operating permits and performs Prevention of Significant Deterioration reviews. Emissions due to the construction of the 1000-acre lake will fall within the conditions of the existing air quality permit.

L.6.6 Noise

DOE is obliged by the Noise Control Act of 1972 to carry out programs in a manner that furthers the national policy of promoting an environment free from noise that jeopardizes health or welfare. The major source of noise would be the construction activity in connection with the embankment for the 1000-acre lake. The contractor would be required to keep construction activities under surveillance, and to exercise control to minimize damage to the environment by noise. The contractor would use methods and devices to control noise emitted by equipment to the levels required in the COE, Savannah District General Safety Requirements Manual (COE, 1981a).

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